SONGBIRD, FOREST OWL AND SMALL MAMMAL DIVERSITY IN MATURE AND HARVESTED ASPEN AND MATURE MIXED-WOOD FORESTS IN THE DAWSON CREEK FOREST DISTRICT:

Summary of Research and Related Survey Projects, 1992-1999

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PREFACE

This report represents a collation of numerous project progress reports prepared by contracting consultants. The primary source is a single report prepared by Merkens and Booth in 1998, summarizing and interpreting much of the data from 1992 to 1997. Results from a subsequent progress report by Phinney and Lance (1999) are also included. For the most part, the data presented in this report were previously analysed and interpreted by the authors of the progress reports, and some sections follow very closely what those authors wrote. However, some additional data tabulation, analysis, interpretation and comparison to recent literature have been incorporated into this Working Report by Darling and Gebauer.

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ABSTRACT

From 1992 to 1999, we assessed species diversity, relative abundance and community dominance of forest songbirds and small mammals in mature (control) and recently harvested, aspen forests near Chetwynd, B.C. Resident owls were surveyed during March-April 1997. We also assessed vegetation cover, security cover, woody debris and wildlife trees in the harvested and control stands. This report focuses on results of the songbird and small mammal study components and highlights the results of the other surveys. The reader is referred to details presented in unpublished annual progress reports.

Small mammal species richness and abundance varied between years and between mature and harvested stands. Multi-year population cycles and stochastic weather events likely accounted for much of the between-year variation. Several mammal species encountered within mature stands during this study were never captured in clearcut areas. Some species were captured exclusively within clearcuts. Only Deer Mouse and Meadow Vole were significantly affected by clearcutting, though the effect of clearcutting was not consistent over the duration of the study. Retention patches of sufficient size within clearcuts may provide interior-forest species with suitable habitat or corridors.

Our forest songbird results are based on "presence" of apparently breeding (i.e., singing or calling) individuals of a species, not whether they are successfully reproducing. Analyses of point-count data indicate that there were significant differences in species abundance between years for 15 of 24 bird species recorded in seven mature stands monitored from 1993 to 1997. However, fluctuations in abundance in mature stands appeared to be part of the normal variation in songbird abundance rather than population trends. Variations in diversity, abundance and dominance patterns were recorded among mature stands and among harvested stands of various age classes. The magnitude of these variations has potentially significant implications for interpretation of short-term "control-versus-treatment" studies.

The number of bird species recorded in mature stands and clearcut stands did not differ within a given year, but numbers varied between years. In all mature stands and clearcuts, there were a few dominant bird species that provided about 80% of the observations, while many species were uncommonly recorded; however, the dominance order (rank) of the species in harvested stands differed from mature stands, reflecting songbird habitat preferences.

Abundance of bird species after clearcutting followed established patterns: (1) no significant change in abundance of some species; (2) a lower abundance of species usually associated with older forests; (3) detections of mature-forest species in the clearcuts, primarily in leave-tree patches; (4) early successional bird species in clearcuts, and (5) significant annual changes in abundance of various species in clearcuts.

Management recommendations stemming from this study include: (1) large, unfragmented mature stands must be distributed across the landscape and over time; (2) retention patches in clearcuts must be large (> 5 ha), connected to intact forest, representative of the intact forest, and include critical elements such as large-diameter live aspen with visible signs of heart rot to maintain nesting habitat for cavity-nesting wildlife; (3) long, large-diameter woody debris and small woody debris must be retained in slash piles and scattered throughout the harvested block where feasible; (4) longer harvest rotations should be scattered across the landscape. Additionally, managers must recognize that significant annual fluctuations in species abundance are normal and may result in misleading interpretation of short-term studies, and that the presence of an apparently breeding songbird does not imply successful breeding. Further study is required on the size and configuration of leave patches, particularly in reference to the role of patches in small mammal and songbird population dynamics and reproductive success. Stands 20 to 60 years old need to be studied to determine at what stand age forest-associated species re-colonize regenerating stands.

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5. M. Phinney and A. Lance (Industrial Forestry Service, Prince George) conducted fieldwork and prepared a report for 1999.

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1 INTRODUCTION

The boreal mixed-wood forest covers a significant proportion of the western Canadian provinces from south and central Manitoba through central Saskatchewan and central and northern Alberta, and into central and northeastern British Columbia and areas in the southern half of Yukon. A mosaic of forest stands varying in age, size and species composition characterizes the boreal mixed-wood forest. This expansive forest is home to a wide diversity of plant and animal species, including several species that are currently considered "at risk" in British Columbia.

Although the mixed-wood forest consists of a "mix" of deciduous and coniferous species, pure stands of either type are typical, with trembling aspen (*Populus tremuloides*) and white spruce (*Picea glauca*) dominating. Natural disturbances such as flooding, insect attacks, windfall and fire, in conjunction with local soil and elevational gradients, shape local stand composition. Fire is by far the most important natural factor that has controlled landscape patterns within these forests. In recent decades, the boreal mixed-wood forests in the northeastern corner of British Columbia have undergone considerable fragmentation. Agricultural practices, road and seismic line construction, harvesting of conifers (and more recently, aspen) and other activities have contributed to an altered regional landscape pattern. Such activities undoubtedly affect the structure and function of forest communities in ways not entirely compatible with natural processes, or they result in habitats containing qualities that are uncharacteristic for the area.

Aspen is the major hardwood species in British Columbia, representing 75-80% of the hardwood timber supply in northeastern British Columbia (Enns et al. 1993). It is harvested domestically for production of waferboard (oriented strandboard), pulp and hog fuel. Commercial use and management are recent, changeable and unpredictable. Traditionally, because of standard harvesting techniques and silvicultural constraints, aspen management in northeastern British Columbia has been based on clearcutting and even-aged stand management.

Massie (1996) determined that over 173 million m^3 of mature aspen are found on > 2 billion ha of aspen-dominated forests in northeastern British Columbia in the Fort Nelson, Fort St. John and Dawson Creek forest districts. There are an additional 46 million m^3 of over-mature (> 121 years old) aspen and 38 million m^3 near mature (61-80 years old) aspen. With an estimated 20-year annual harvest of over 5.6 million m^3 (Massie 1996), the potential for significant harvest impacts on wildlife is high.

Maintaining biological diversity in managed forest ecosystems requires an understanding of the effects of silviculture practices on wildlife populations. In aspen-dominated forests, the changes in vegetation structure and composition after clearcutting cause local changes in animal populations (Gullion 1997), but the nature of these changes depends on regional wildlife composition.

The list of wildlife species in British Columbia that are dependent on hardwood trees or on hardwood forests is impressive (Enns et al. 1993, Pojar 1995, Fenger 1996). Critical parameters of the forest upon which wildlife may depend include: stand age, origin and disturbance interval; canopy cover; percentage deciduous and coniferous; amount and character of understory; litterfall and dead wood accumulations; mean diameter and height; number of dead and dying trees; and amount and type of rot, decay and disease. There are many hardwood-dependent species whose habitat requirements and status are poorly known. Of particular importance is the potential loss or change of critical deciduous habitat elements in the forest (Enns et al. 1993).

2 OBJECTIVES

The overall objectives of the study are to:

1. Assess the effect on wildlife diversity of clearcut harvesting in aspen forests of the Dawson Creek Forest District.
2. Examine potential linkages between changes in wildlife diversity and changes in forest structure and plant diversity associated with clearcut harvesting in aspen forests of the Dawson Creek Forest District.
3. Contribute to guidelines for the maintenance or enhancement of wildlife diversity in managed aspen forests.

In this study, forest songbird and small rodent communities were selected to address the effects of harvesting on wildlife diversity. Therefore, Objective #1 is subdivided as follows:

A) Assess the effect of clearcut harvesting in aspen forests on the number of species, relative abundance and community dominance patterns of forest songbird communities.

B) Assess the effect of clearcut harvesting in aspen forests on the number of species, relative abundance and community dominance patterns of small mammal communities.

In this study, changes in forest structure were assessed in terms of horizontal cover, diversity and percent cover of plant species in various forest layers; density and character of wildlife trees; and volume and character of woody debris. Therefore Objective #2 is subdivided as follows:

A) List and estimate the percent cover of all plant species within different layers within the forest.

B) Calculate an index of horizontal cover < 2 m, including shrubs, woody debris, rocks and terrain.

C) Describe and quantify wildlife trees in mature and regenerating aspen and mixed-wood stands, and describe nest trees and nest-tree sites selected by cavity-nesting birds in aspen stands.

D) Describe and quantify coarse woody debris in mature aspen and mixed-wood stands.

(Results of the wildlife tree and woody debris work are presented in Merkens and Booth [1997], Manning and Chytyk [1997] and Manning et al. [2001] and will not be discussed in this report.)

Short-term surveys were added to supplement the study of the effects of harvesting on wildlife diversity in aspen forests. The objectives of these surveys were:

1. To examine the abundance and diversity of owls in aspen and mixed-wood stands.
2. To examine the abundance and diversity of forest songbirds in mixed-wood stands.

The objective of this Working Report is to present, highlight and summarize preliminary results of the ongoing study and related, complementary surveys in a report series that will be more widely circulated and more readily available to stakeholders and wildlife managers than the unpublished progress reports prepared by consultants. The interested reader is referred to the original consultant reports.

3 STUDY AREA AND STUDY DESIGN

3.1 Aspen Study

The Del Rio study area, approximately 60 km northeast of Chetwynd B.C., and the Tate Creek study area, approximately 50 km south of Dawson Creek, B.C. (Figure 1) lie in the Boreal White and Black Spruce moist, warm (BWBSmw1) biogeoclimatic subzone and the wet, cool (BWBSwk1) subzone, respectively. Mature stands in both areas that were classified on B.C. Forest Service forest cover maps as pure aspen were aspen dominated with small patches of white spruce scattered throughout. (In this report, these are referred to as "aspen stands"). There was a small cottonwood (*Populus balsamifera* ssp *balsamifera*) component that reached the canopy and a smaller birch (*Betula papyrifera*) component in the understory. Spruce and lodgepole pine (*Pinus contorta* ssp *latifolia*) occurred sporadically below the canopy. Mature stands were generally of uniform age (60-100 years), with a uniform canopy about 20-25 m high and a dense understory, usually <2 m high. The terrain was flat to gently rolling.

In both study areas, the fundamental study design included surveys of forest birds, small rodents, vegetation, wildlife trees and coarse woody debris before and after harvest on control and treatment (harvest) blocks. The Del Rio study area was the more intensively sampled of the two study areas. Fifteen study blocks were established and surveyed in the Del Rio during 1992-1999 (Table 1). No surveys were conducted in 1998 because of insufficient funding and no new harvesting. In 1992, nine unharvested blocks in the Del Rio area (six scheduled for harvest in 1993 and 1994 and three controls) were surveyed. In 1993 an additional mature stand was added to serve as a control. Because of delays in harvesting, two three-year-old clearcuts were added in the Del Rio study area in 1994. (Blocks in this study were winter harvested; they are nominally "one-year-old" cutblocks the following summer.) These two stands were surveyed until 1999 and represent a chronosequence of three-, four-, five-, six- and eight-year-old clearcuts. In the winter of 1994-95, three of the study blocks in the Del Rio were harvested. These newly created clearcuts were surveyed from 1995 to 1999 and represent a chronosequence of one-, two-, three- and five-year-old clearcuts. In 1997 three one-year-old clearcuts were added to the Del Rio study area; due to access difficulties, only two were included in surveys in 1999.

The Tate Creek study area was sampled only during 1992-1995 (Table 1); reduced funding and access difficulties forced its termination. In the Tate Creek study area, three mature stands (two to be harvested and one control) were sampled in 1992. In 1993 an additional control block was added. Two treatment blocks were harvested in the winter of 1992-93. These two blocks

represent a chronosequence of one-, two-, and three-year-old clearcuts.

3.2 Mixed-wood Surveys

Forest birds, vegetation, wildlife trees and coarse woody debris were sampled in 1995 in mixed-wood stands at the Murray River study area, on the east side of the Murray River, near Groundbirch, B.C. (Figure 1). This site is within the BWBSmw1 biogeoclimatic subzone. Stands were selected from polygons on B.C. Forest Service forest cover maps that were labelled age class 5 or older and deciduous- or coniferous-leading (e.g., aspen/spruce or spruce/aspen cover types). Eleven survey stations were established in five stands (three aspen-leading and two conifer-leading) for a one-time comparison between forest-cover types. This work was a pilot study; no habitat assessment or small mammal surveys were conducted and the work was not funded in subsequent years.

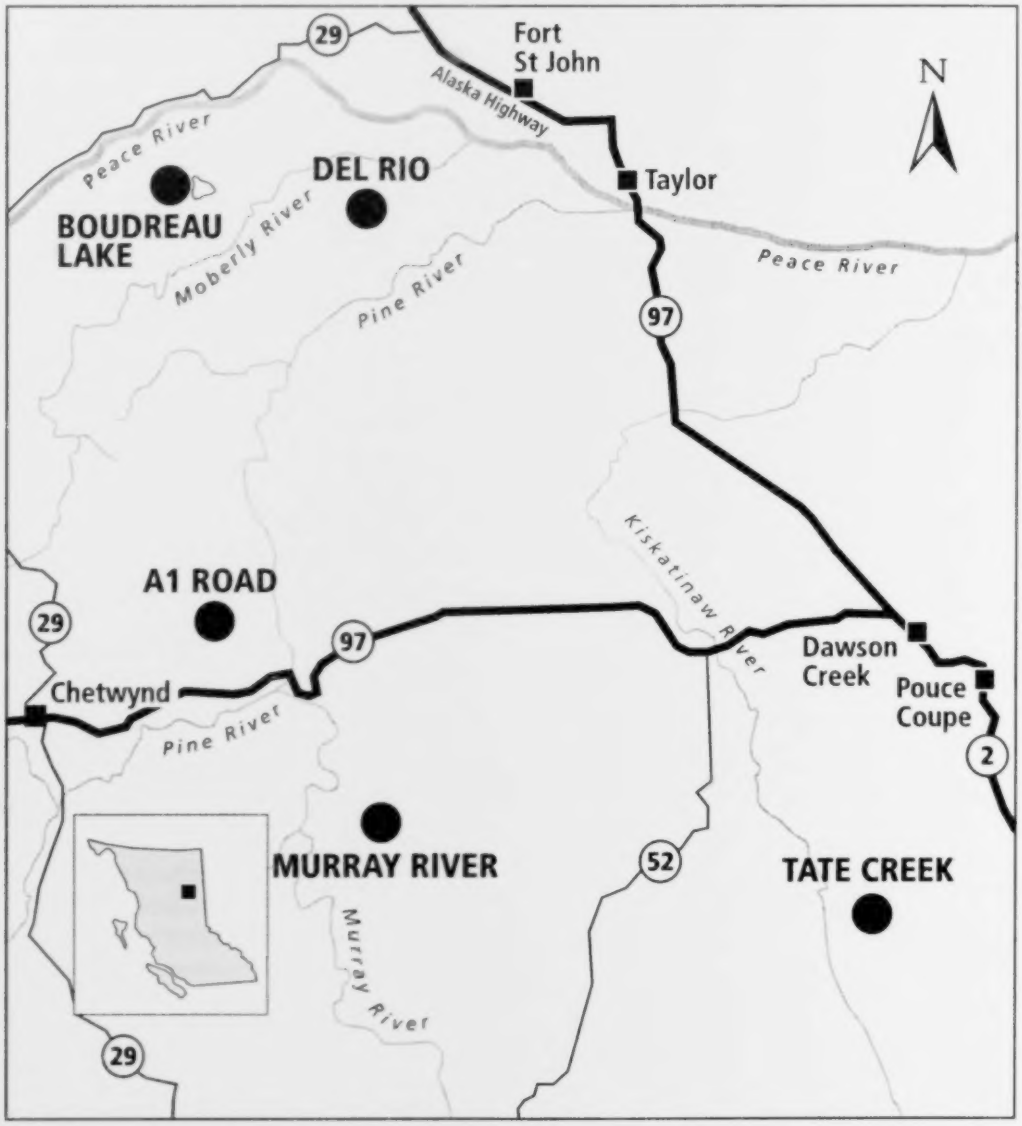

Figure 1. Location of two aspen study sites, Del Rio and Tate Creek, and three mixed-wood study sites, Boudreau Lake, Murray River and A1 Road, in northeastern British Columbia.

3.3 Owl Surveys

Surveys for forest owls were conducted during March-April 1997 in aspen forests of the Del Rio and mixed-wood forests of the Boudreau Lake and Murray River areas and the A1 Road near the Louisiana-Pacific pulpmill northeast of Chetwynd (Figure 1). The Del Rio and Murray River sites are described above. The Boudreau Lake and A1 Road areas also fall within the BWBSmw1 biogeoclimatic subzone. The mixed-wood stands were composed of deciduous and coniferous species, primarily aspen and white spruce, but included black spruce, lodgepole pine, cottonwood and birch, and various combinations of stand type and age. Multiple visits to 57 calling stations in the Del Rio and 26 stations in the three mixed-wood stands allowed one-time comparisons between forest types.

4 METHODS

4.1 Forest Bird Surveys – Aspen Stands

Forest birds were surveyed at the Del Rio and Tate Creek aspen study blocks using a fixed-radius (80 m) point-count method (Reynolds et al. 1980, Verner 1985). Each study block had four to six permanently established bird survey stations at least 160 m apart. Following the established sampling design of Darling and Farr (1994), two bird stations in each of two to four blocks were selected at random on each survey day. Counting began at sunrise, and, depending on distance between blocks, two to four stations were surveyed each day. Birds were recorded during two sequential five-minute intervals following a one-minute period of silence upon arrival at each station.

Point-count survey effort varied between years and was discontinued at Tate Creek after 1995. In 1992 blocks at Del Rio and Tate Creek were visited on only one day during the breeding season. These data have been tabulated and compared visually, but they have been excluded from statistical analysis. In 1993-1995, 1997 and 1999, birds in each study block were surveyed on six different days over the course of the sampling frame, providing 12 surveys per block each year. Due to delays in securing funding in 1996, blocks in the Del Rio area were surveyed on only four different days (eight surveys per block).

Species detected within each stand beyond the survey radius or outside the 10-minute survey period were also recorded to generate an "incidental" species list for each study block. In order to assess the role of retention patches or individual retention trees in cut-blocks, bird use of these habitat attributes was noted during surveys in 1996 and 1997. In 1999, travel routes between adjacent bird survey stations were used as transect lines if, on a given day, two neighbouring survey stations were chosen for point counts. The observer recorded all birds encountered within 40 m of the travel route between the stations to assess differences between point-count and transect data.

4.2 Forest Bird Data Analysis – Aspen Stands

Analyses were conducted using the Del Rio songbird data, 1993-1999. The 1992 field methods were not sufficiently similar to the following years, so 1992 data was excluded. The Tate Creek data set was hampered by sample size (too few blocks for within-site comparisons) and was sufficiently different that data from there could not be pooled with the Del Rio site.

Presented in this report are results from analyses conducted on the 1993-1997 data (Merkens and Booth 1998a) and from analyses of the 1999 data alone (Phinney and Lance 1999). Although funds were not available to conduct analyses of the full 1993-1999 data set for this report, the current authors note substantial similarities and differences between the 1999 data and related analytical results from the previous years.

4.2.1 Within-year differences in richness and abundance – mature stands

Phinney and Lance (1999) assessed within-year differences in abundance in the 1999 data for mature stands (four control blocks) by fitting the log-likelihood estimator G to the null hypothesis of no difference (alpha >= 0.05). Within-year differences in the 1993-1997 data were not analyzed statistically.

4.2.2 Effects of year on abundance in mature stands

Merkens and Booth (1998a) used repeated-measures ANOVA ((=0.05) to examine annual changes in abundance (number of individuals detected) of 24 species detected in seven mature stands in the Del Rio area from 1993 to 1997 (Tables 1 and 2). For those species for which significant annual differences were found,

mean numbers of detections per point count per block were plotted with standard errors to determine which year(s) was (were) different.

4.2.3 Effects of harvesting on abundance

To examine the differences in abundance (number of individuals detected) of 29 species (Table 2) in mature, old and young clearcuts (harvested in winter 1991-1992 and 1994-1995, respectively) we used data from 1995-1997 in a repeated-measures ANOVA. Where the assumption of sphericity of the covariance matrix (Mauchly's test) was violated, Pillais' multivariate test was used to determine year and year-by-age effects (SPSS 1994). For those species for which significant differences were found between different stand ages, we plotted means and standard errors of detections per point count per block in each stand age to visually examine differences between stand ages. We used one-way ANOVAs with Duncan's multiple range tests to determine which stand age(s) was (were) different from each other. Interactions of the effects of year and stand age were examined graphically to determine where differences existed. In addition, one-way ANOVAs using Duncan's multiple range tests were used to examine the abundance of each bird species in each stand age in each year to determine how stand age interacted with year. Significant differences in species abundance in different years were interpreted only as they pertained to significant interactions between year and stand age.

4.2.4 Effects of year on species richness

Data from 12 Del Rio study blocks in 1995-1997 were used by Merkens and Booth (1998a) in comparisons of bird species richness among seven mature stands, three younger cut-blocks and two older cut-blocks (Table 1). The total number of species detected annually in each block was used as the estimate of species richness. Repeated-measures ANOVA was used to compare the number of species among years. One analysis compared the total number of species detected during surveys in each block, including ducks, owls and other species that are most often detected when flying over the stand. Another analysis compared the total number of species recorded in each stand, including incidental records and all species detected during surveys. A paired t-test was used to determine in which year(s) species richness was significantly different.

The differences and similarities in the total number of species observed in each study block were assessed graphically for the 1999 data.

4.2.5 Effects of harvesting on community dominance

To examine community structure, we plotted dominance curves using the mean number of detections per point count per block for each species in mature stands for data from 1997 (this year was selected because the data included the widest range of stand ages). Species detected in harvested blocks but not in mature stands were plotted as zero values on this curve. The mature curve was then overlaid (in the same species detection rank order as in mature stands) with the mean number of detections per point count per block in one-, three- and six-year-old clearcuts. Plotting the abundance of each species in this way facilitated the examination of the potential differences in abundance of each species, and hence differences in community structure between each stand age.

4.3 Forest Bird Surveys and Analyses – Mixed-wood Stands

Forest birds were surveyed at six survey stations in three deciduous-leading mixed-wood stands and at five stations in two coniferous-leading mixed-wood stands. Each station was surveyed five times using the fixed-radius (80 m) point-count method described above for aspen stands. (Further details in Booth 1996.)

Species richness in mixed-wood stands was measured using the number of different species observed at each bird station; a t-test was used to test for differences between deciduous-leading and coniferous-leading stands.

Abundance analysis compared the number of detections of species guilds – four nesting and four feeding guilds – at each survey station and for each survey. A t-test was used to test differences in abundance between forest types. Results are presented in Merkens and Booth (1998a).

Dominance curves of the mean number of detections by species were used to identify differences in overall community structure in mixed-wood stands. Curves of coniferous-leading forest stands were overlaid on curves of the deciduous-leading forest stands with the species in rank order of the latter. Results are presented in Merkens and Booth (1998a).

4.4 Forest Owl Surveys and Analyses

Forest owls were surveyed using call-playback surveys from stations >800 m apart along roads and seismic lines in aspen and mixed-wood stands in four areas in the Dawson Creek Forest District, from mid-March to mid-April 1997 (see Booth and Harrison 1997). Calls of Great Horned, Great Gray and Northern Saw-whet owls were broadcast at 57 calling stations (122 calling-station nights) in the aspen forests of the Del Rio. At 26 calling stations (68 calling-station nights) in mixed-wood forests in the Boudreau, Murray River and A1 Road study areas, calls of Barred and Boreal owls were broadcast. When owls were detected, their direction and distance from the calling station were estimated. (Further details are presented in Booth and Harrison 1997). The detection rate in a study area was determined from the number of detections per species divided by the number of calling-station nights.

To examine nightly activity peaks, Booth and Harrison (1997) plotted the percent of the total number of detections that occurred in three time classes: 1900-2159 h, 2200-2359 h and 2400-0300 h. Weekly activity patterns were determined from the sum of the number of owls detected during each week of the survey. These results are presented in Booth and Harrison (1997).

4.5 Security Cover Surveys and Analyses

Estimates of security cover were made at randomly selected bird and or mammal survey stations within harvested and mature aspen study blocks at Del Rio and Tate Creek. A wide range of samples was taken in each study block, once before and one to three times after harvest, depending on the age of cut (Tables 3 and 4). Security cover was sampled by estimating the percentage of a 20 x 20 cm square card covered by herbs, shrubs, trees, coarse woody material and topography at two observer heights (0 and 1 m), four card heights (0, 0.5, 1 and 2 m), and seven card distances (1, 2, 3, 4, 5, 10, and 15 m). Four samples of security cover were taken at each sampling point, one along each cardinal compass bearing. Security cover was sampled from late June to early July.

Merkens and Booth (1998a) calculated mean values for cover (composed of vegetation, coarse woody debris and topography) for all combinations of card height, card distance and observer height within stand-age classes. The means for each cardinal direction of each sampling plot were plotted and visually compared among mature and regenerating aspen stands in the Del Rio. Between-year differences were considered negligible.

4.6 Vegetation Surveys and Analyses

Vegetation abundance and diversity were assessed within 20 x 20 m plots (Luttmerding et al. 1990) in mature and harvested study blocks at Del Rio and Tate Creek. Plots were established at randomly selected bird stations in harvested and mature study blocks from 1993 to 1999 (Tables 3 and 4). A list of all plant species encountered within the plot area was assembled. Vegetation composition within tree (>10 m), shrub (in four strata: 0-1 m, 1-2 m, 2-5 m and 5-10 m) and herb layers was visually estimated as percent cover for each species encountered. Overall percent cover by layer was also estimated. Plant communities were sampled from late June to early July.

The incidence of all plant species encountered within mature and cut-block areas was graphically compared (see Merkens and Booth 1998a). Incidence was calculated as the proportion of sample plots within mature or cut-block areas (all cut ages combined) with a particular species present. Species richness within herb, shrub (all shrub strata combined) and tree species was compared between stand ages using ANOVA. Differences among stand ages were determined by Duncan's Multiple Range tests (SPSS 1994).

Percent cover data were arcsine transformed prior to analysis. Merkens and Booth (1998a) used ANOVA to compare overall percent cover in two low-vegetation strata (herb and shrub < 1 m) among stand ages. Differences among stand ages were determined by Duncan's Multiple Range test (SPSS 1994). Percent cover in the mid-height shrub layers (1-2 m and 2-5 m) was compared among stand ages using Kruskal-Wallis non-parametric ANOVA because of unequal variances. Shrubs > 5 m and trees occurred only in mature stands. Between-year differences were assumed to be negligible.

4.7 Small Mammal Surveys

Index trap lines (Ritchie and Sullivan 1989) were used to sample small mammal populations in aspen forests at Del Rio and Tate Creek from 1992 to 1997. No small mammal surveys were conducted in 1999. One index line was established in each study block. In Del Rio, each line was 300 m long and contained 40 Sherman

traps, 10 Tomahawk traps and varying numbers of functioning pitfall traps. Pitfall arrays were established at five equally spaced trap stations in each study block. Each array consisted of four pits (one central and three radial at 3.5 m distance) joined by 25-cm-high plastic sheeting or overlapping lengths of coarse woody debris serving as drift fences. Because of varying and generally high water table levels, pitfall traps were not always functional, so the number of active pitfalls varied between blocks and sampling dates. Pitfall traps were not used in 1996 and 1997. In Tate Creek blocks, each line was 150 m long and contained 20 Sherman traps, five Tomahawk traps and varying numbers of active pitfall traps. In both study areas, Sherman traps were set in pairs at 15-m intervals, and single Tomahawk traps were set at 30-m intervals. Sherman traps were baited with peanut butter and rolled oats, and Tomahawk traps were baited with strawberry jam and marten lure. Pitfall traps were not baited.

In most study years, traps were set for two consecutive nights during each of four trapping sessions, three during May and June and one in late August/early September. During 1994, fall trapping efforts were reduced to 10 trapping stations per block on all blocks surveyed in Del Rio, and trapping did not occur on three Del Rio blocks or at Tate Creek (Table 5). During 1996, due to late funding commitments, only three trapping sessions were conducted, two during May and June and one in late August/early September. All captured animals were weighed, identified to species when possible, and gender, age class and breeding condition were determined. Live captures were tagged using fish fingerling tags or, for animals previously tagged, the tag number was recorded.

4.8 Small Mammal Data Analysis

4.8.1 General and mature stands

Capture data were standardized to new captures per 100 trap-nights for all analyses with May-June trapping sessions combined and August-September sessions analyzed as separate sampling periods. Considerable variation in capture rates (abundance) between years was noticed. Repeated-measures ANOVA was used to assess between-year differences in abundance of Deer Mouse, Meadow Vole and Red-backed Vole (see Appendix A for scientific and common names of species referred to in this report) on seven unharvested study blocks for which five complete years of data were available (Table 5). Between-year differences among harvested study blocks were not assessed because of the confounding effects of harvesting on abundance.

4.8.2 Effects of harvesting

The effect of aspen harvest on small mammal abundance and richness was analyzed using repeated-measures ANOVA supplemented by Pillais's multivariate test wherever the assumption of sphericity of the data was violated (Mauchley's test: SPSS 1994). Deer Mouse, Red-backed Vole and Meadow Vole abundance (capture rate) was analyzed using data from 1995-1997 (Table 5) from mature stands and young and old clearcuts (harvested in winter 1991-1992 and 1994-1995, respectively). Spring and fall capture data were analyzed separately. For species that showed significant stand-age effects or stand-age-by-year effects, follow up one-way ANOVAs and Duncan's Multiple Range Tests were conducted within years to determine which stand ages were different from one another.

4.8.3 Effects of stand age on species abundance in 1997

Stand-age effects on Deer Mouse, Red-backed Vole and Meadow Vole abundance (capture rate) were analyzed by repeated-measures ANOVA using data from the four sampling sessions conducted in 1997, at which time the harvested blocks were six-, three- and one-year-old clearcuts. For species that showed significant stand-age effects, follow up one-way ANOVAs and Duncan's Multiple Range Tests were conducted within sessions to determine which stand ages were different from one another.

5 RESULTS

5.1 Forest Songbirds in Aspen Stands

5.1.1 Overall bird diversity and abundance

Over the seven-year study at the Del Rio study site (1992-1997, 1999), 82 bird species (see Appendix A for scientific names and codes) were recorded during the fixed-radius point-count surveys in mature and harvested aspen study blocks. An additional 18 species were seen outside the 10-minute survey periods but

within the study plots. The four blocks at Tate Creek were surveyed for four years (1992-1995). A total of 59 species was observed during surveys, with an additional 15 species seen incidentally on the study blocks. The difference in number of species between the two sites is primarily due to the fewer blocks and years surveyed at Tate Creek.

Totals of 7242 and 1134 individuals were recorded at Del Rio and Tate Creek, respectively, resulting in a mean of 86 individual birds/block/year at Del Rio and 77 birds/block/year at Tate Creek.

The 10 most common bird species detected at Del Rio and Tate Creek are summarized in Table 6. These species account for 63% and 57% of the total individuals recorded at Del Rio and Tate Creek, respectively. The White-throated Sparrow is by far the most common species at both sites. The Least Flycatcher is also very common at both sites but is more than two times as abundant at Del Rio than at Tate Creek. Four other species, Yellow Warbler, Lincoln's Sparrow, Yellow-rumped Warbler and Brown-headed Cowbird, were also within the top 10 most abundant species at both sites. Swainson's Thrush, Ovenbird and Yellow-bellied Sapsucker, which are generally found in aspen-dominated habitats, were much more common at Del Rio than at Tate Creek, reflecting the differences in biogeoclimatic subzone and the fact that aspen is more uniform at Del Rio than at Tate Creek.

Rare and endangered species (i.e., blue or red-listed; Conservation Data Centre 2000) are found at both sites, although generally at very low densities (Table 7). The most common of these species is the Philadelphia Vireo, which shares similar habitat with the Red-eyed, Blue-headed and Warbling vireos.

Merkens and Booth (1998a) used repeated-measures ANOVAs to examine species richness between years (i.e., 1995-1997). When survey data such as fly-overs, ducks and owls were included in the analysis, a significant year effect ($F_{(2,18)}$, p=0.001) was observed for control and harvested blocks combined (Table 8). Follow-up t-tests showed that there were fewer species detected per block in 1996 than in either 1995 or 1997 (Table 8). A similar analysis that included all incidentals also found that fewer species were found per block in 1996 than in either 1995 or 1997 and that more species were detected per block in 1995 than in 1997 (see Table 9). This result may be due to the fewer visits in 1996 than in 1995 and 1997 (i.e., eight versus 12 surveys per block, respectively). This may also be a function of only three years of data – with more years in the analysis, the low values of 1996 may be muted (see section 6.1.3).

Bird species diversity recorded during trial transect counts in 1999 was lower than recorded in point counts, while number of individuals was higher during transect counts (Phinney and Lance 1999). The numbers indicate differences in efficiency or effectiveness of the two methods, but Lance and Phinney (1999) speculated that differences reflect spatial and temporal differences in the methods that favour or disfavour scarce and cryptic species. Our study was designed to address changes in species diversity – the point-count method appears to better address number of species in an area but not density.

5.1.2 Mature aspen stands

Bird Richness and Abundance—During the seven years of the study at Del Rio, the total number of bird species recorded in mature aspen stands during surveys ranged from a low of 33 species in 1999 (four mature blocks) to 41 species in 1993 (10 mature blocks). A further 10 to 20 species were reported as incidentals (see Table 10). At Tate Creek, the total number of species recorded ranged from a low of 24 in 1994 (two mature blocks) to a high of 32 in 1993 and 1995 (two mature blocks). High species counts occurred in 1993 at both study sites. Overall lower numbers of species reported in mature blocks at Tate Creek are likely related to fewer mature blocks surveyed (see Table 10).

The mean number of individual birds per block recorded in mature aspen stands at Del Rio ranged from a low of 59.5 individuals/block in 1994 to a high of 111.4 individuals/block in 1993 (Table 11). At Tate Creek, the mean number of individuals recorded in mature aspen stands ranged from a low of 57 individuals/block in 1994 to a high of 103.5 individuals/block in 1993. Highs and lows were recorded in the same years at both Del Rio and Tate Creek, suggesting that variations between years occur across large areas.

Phinney and Lance (1999) found significant differences in abundance among the four mature study blocks at Del Rio in 1999 – block B1 had a greater number of species and more detections of common species and fewer of uncommon species than the other three control blocks.

Annual Variation in Abundance in Mature Stands—Merkens and Booth (1998a) used repeated-measures ANOVAs to investigate the year-to-year changes in abundance of 24 species that were recorded in mature stands at least 10 times in any year between 1993 and 1997. (Data from 1992 were excluded from the analysis because blocks were visited only once during the breeding season.) Significant between-year differences in the abundance of 15 of the 24 species were determined (Table 12). (No significant annual difference in abundance was found for nine common species: Black-throated Green Warbler, Gray Jay, Northern Waterthrush, Orange-crowned Warbler, Solitary Sandpiper, Warbling Vireo, Western Tanager, Yellow-bellied Sapsucker and Yellow-rumped Warbler.) For 11 species, 1993 and 1994 represented years when detections were quite low in mature stands. On the other hand, Red-breasted Nuthatch and Dark-eyed Junco were detected more often in 1993 and 1994 than in any other year. Tennessee Warbler was detected at low levels in 1993 and 1994, was not detected in 1995 but was frequently detected in the last two years of the study. Lincoln's Sparrow was detected at very low levels in every year except in 1995, when it was detected at much higher levels than in any other year.

Results in 1999 for most species fell within the range of results between 1993 and 1997 (Table 12). Exceptions included Lincoln's Sparrow and Philadelphia Vireo (0.02), which were detected at lower densities than between 1993 and 1997, and Yellow Warbler, which was recorded at higher densities in 1999 (0.88) than in other years (0.25 to 0.76). These results could not be accounted for by the differences in composition of mature forest blocks in 1999 (i.e., four blocks) and 1993-1997 (i.e., seven blocks).

Differences in abundance within the 1999 data were not significant for the younger clearcuts (one- and three-year-old) (Phinney and Lance 1999). One of the five-year-old cutblocks (DM) had substantially more detections and about twice as many species as the other five-year-old cutblocks. In the two eight-year-old cutblocks, the total number of detections and the number of species were similar; however, the abundance of individual species varied and resulted in a significant difference in abundance within this age class.

5.1.3 Harvested aspen stands

Bird Abundance—The mean number of individual bird species detected for similarly aged blocks varied greatly among years at both Del Rio and Tate Creek (Table 13). Differences within years at different-aged stands were also evident. The highest abundance of birds occurred in the oldest harvested areas. The lowest abundance of birds was reported in the one- to two-year-old harvested blocks.

Table 14 and Figure 2 compare bird abundance at Del Rio in six blocks where surveys were conducted before and after harvesting and in four control blocks. Although these data were not analysed statistically,

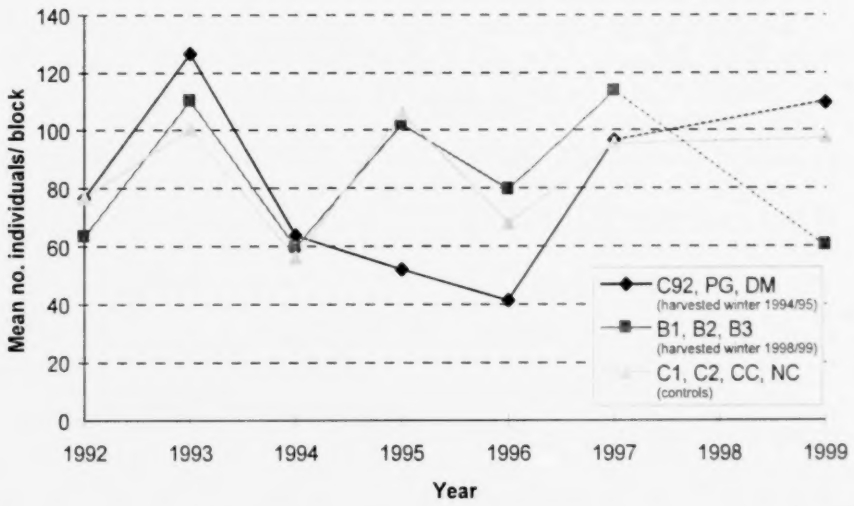

Figure 2. Mean bird abundance in blocks surveyed before and after harvesting, Del Rio, 1992-1999.

some patterns are emerging. Although fluctuations occur between years in mature stands (i.e., similar year-to-year fluctuations observed in all sets of blocks; Figure 2), shortly after harvesting (i.e., one to two years) the overall abundance of birds dropped (see C92, PG and DM as one-year-old clearcut in 1995, Figure 2). By the time the blocks were three years old (1997), the abundance of birds had increased dramatically. The overall abundance of birds may continue to increase with harvested block age, even surpassing overall abundance in mature blocks. Two harvested blocks established in the study at the three-year-old stage in 1994 contributed the highest numbers of individuals recorded in 1995 when they were four years old; their influence is felt through 1999 and may bias our assessment of blocks over three years old. A similar post-harvest pattern is apparent in the four years at Tate Creek (Table 14). It will be important to continue to follow these blocks to see whether this hypothesis is verified.

Merkens and Booth (1998a) used repeated-measures ANOVAs on the 1995 to 1997 data to assess differences in species point-count abundance between mature and harvested (i.e., the young and old) study blocks, combined over 1995 to 1997 (Table 15). New clearcuts were the three stands (C92, DM and PG) that were one-year-old clearcuts in 1995; old clearcuts were the two stands (TC and PS) that were three-year-old clearcuts in 1995. Seven species showed no significant differences in abundance among mature, young and old clearcuts: Least Flycatcher, Black-throated Green Warbler, Gray Jay, Northern Waterthrush, Solitary Sandpiper, Warbling Vireo and Red-breasted Nuthatch. Twelve species showed significant differences between stand ages (Table 16). Duncan's multiple range tests indicated that seven species were more abundant in mature stands than in either young or older clearcut areas, two species were more abundant in mature stands than in young clearcuts, and two species were more abundant in both mature stands and old clearcuts than in young cuts. Only one species was more abundant in young clearcuts than either mature stands or old clearcuts.

Species Richness—Merkens and Booth (1998a) used repeated-measures ANOVAs to examine differences in species richness between mature and harvested study blocks using 1995-1997 data that included incidental species. They found no significant differences in species richness between mature, young or old clearcuts, but there was a strong year effect ($F_{(4,18)}$ =15.33, p<0.001).

When mean species richness per block using only survey data is calculated for each year in stands of varying ages, some differences are noticeable (Table 17). The lower numbers of species observed in 1992 was likely due to the fewer visits (only one day) than in other years (four to six days). The highest mean number of species per block was recorded in the older clearcuts at the Del Rio study site (Figure 3). This may be because of higher habitat heterogeneity in clearcuts, which attracts a wide diversity of species, and/or increased ability of observers to detect non-vocalizing birds. Differences may also be due to block-specific heterogeneity (i.e., retention patches in some blocks) that complicates comparisons between stand ages. For example, the two three-year-old clearcuts added in 1994 make a significant contribution in species numbers to all cutblock ages to 1999.

When stand-age results are compared visually for blocks sampled before and after clearcutting, differences in species richness are also evident (see Table 18). The stand age with the highest species richness at Del Rio was the five-year-old clearcut (i.e., C92, PG and DM). At Tate Creek, the highest number of species was recorded in 1993 and 1995 in the mature blocks. Not enough data is available at Tate Creek to determine whether number of species increases in older clearcuts. Ongoing surveys at Del Rio will confirm whether species richness consistently increases with cutblock age.

Species Composition

Bird communities examined in 1997 by Merkens and Booth (1998a) for each of the stand-age classes showed a characteristic pattern, with few species detected frequently and many species detected infrequently. When species dominance curves for each of the four stand ages present in 1997 (i.e., mature, one-, three- and six-year-old) are overlaid (see Figure 4), there is a strong divergence of curve shapes, indicating that bird communities within the stands are very different.

Species Dominance

The 10 most common species recorded within each stand-age class at the Del Rio and Tate Creek study areas were generally very consistent between years (see Appendix B). At Del Rio, the five most consistently dominant species in mature stands were Least Flycatcher, White-throated Sparrow, Swainson's

Thrush, Yellow Warbler and Ovenbird (Table 19). Of these, only the White-throated Sparrow was within the five most common species in any of the harvested areas. Common species in recently harvested areas (i.e., one- to two-year-old) were dominated by three species: White-throated Sparrow, Lincoln's Sparrow and Dark-eyed Junco. Dark-eyed Junco did not appear in the top five of older harvested areas in Del Rio. In three- to four-year-old and five- to six-year-old harvested areas, the top five species were the same: Clay-colored Sparrow, Lincoln's Sparrow, White-throated Sparrow, Common Yellowthroat and Alder Flycatcher. With the exception of White-throated Sparrow, none of the other four species were represented in the top 10 common species in mature forests in Del Rio. In the oldest harvested blocks, the most common species are very different than at earlier seral stages. Lincoln's Sparrow does not feature as dominantly in the older cutblocks, whereas Yellow Warbler has become the most common species. Care should be taken in interpreting the results of the seven- to eight-year-old stand, since values represent only one year of data.

At Tate Creek, there were fewer species observed and the dominance patterns were more variable (Table 20), presumably because of the fewer blocks surveyed over fewer years than at Del Rio. The top five species observed at Del Rio are also found within the top 10 species at Tate Creek. Similar to Del Rio, White-throated Sparrow was relatively common in young clearcuts. Species that were common in young clearcuts but occurred at low abundance in mature stands include Lincoln's Sparrow, American Robin, Dark-eyed Junco, Clay-colored Sparrow, Cedar Waxwing, Northern Flicker, Alder Flycatcher, Savannah Sparrow, Red-winged Blackbird, Brown-headed Cowbird and Pine Siskin.

Rare and endangered species

Rare and endangered species did not occur in the Del Rio or Tate Creek study areas in great numbers (Table 21). At Del Rio, the blue-listed Philadelphia Vireo was the most commonly observed rare species and even ranked within the top 15 common birds in mature aspen forests. The Philadelphia Vireo was significantly more abundant in mature stands than in either young or old clearcuts (Tables 15 and 16). Black-throated Green Warbler (blue-listed) and Connecticut Warbler (red-listed) occurred at low densities in mature aspen forests. Le Conte's Sparrow (blue-listed) was recorded only in five- to eight-year-old cutblocks (Table 21).

Interactions between Stand Age and Year—Repeated-measures ANOVA was used to test for the effect of interactions between stand age and year on abundance (Merkens and Booth 1998a). Stands were mature, young cuts (one, two, and three years old) and

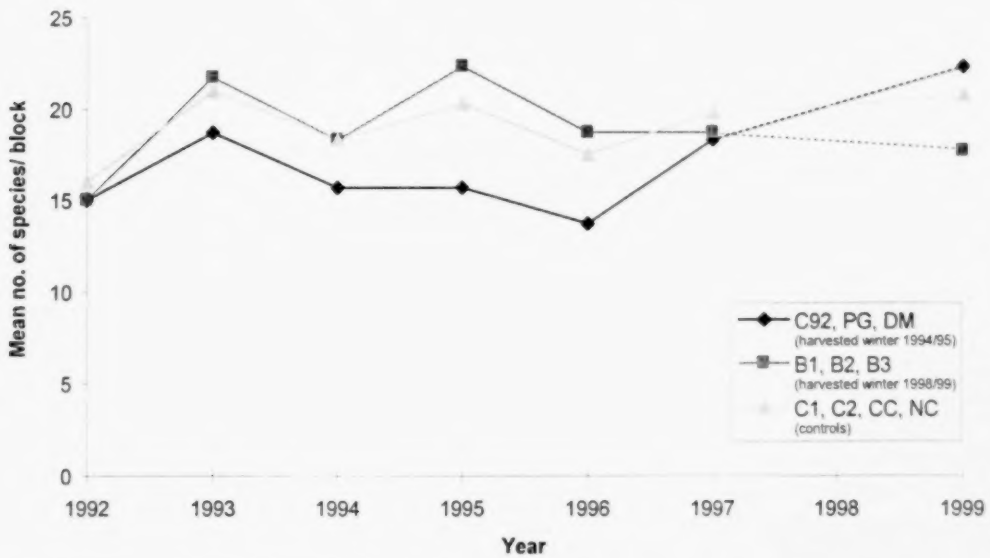

Figure 3. Mean number of bird species in blocks surveyed before and after harvesting, Del Rio, 1992-1999.

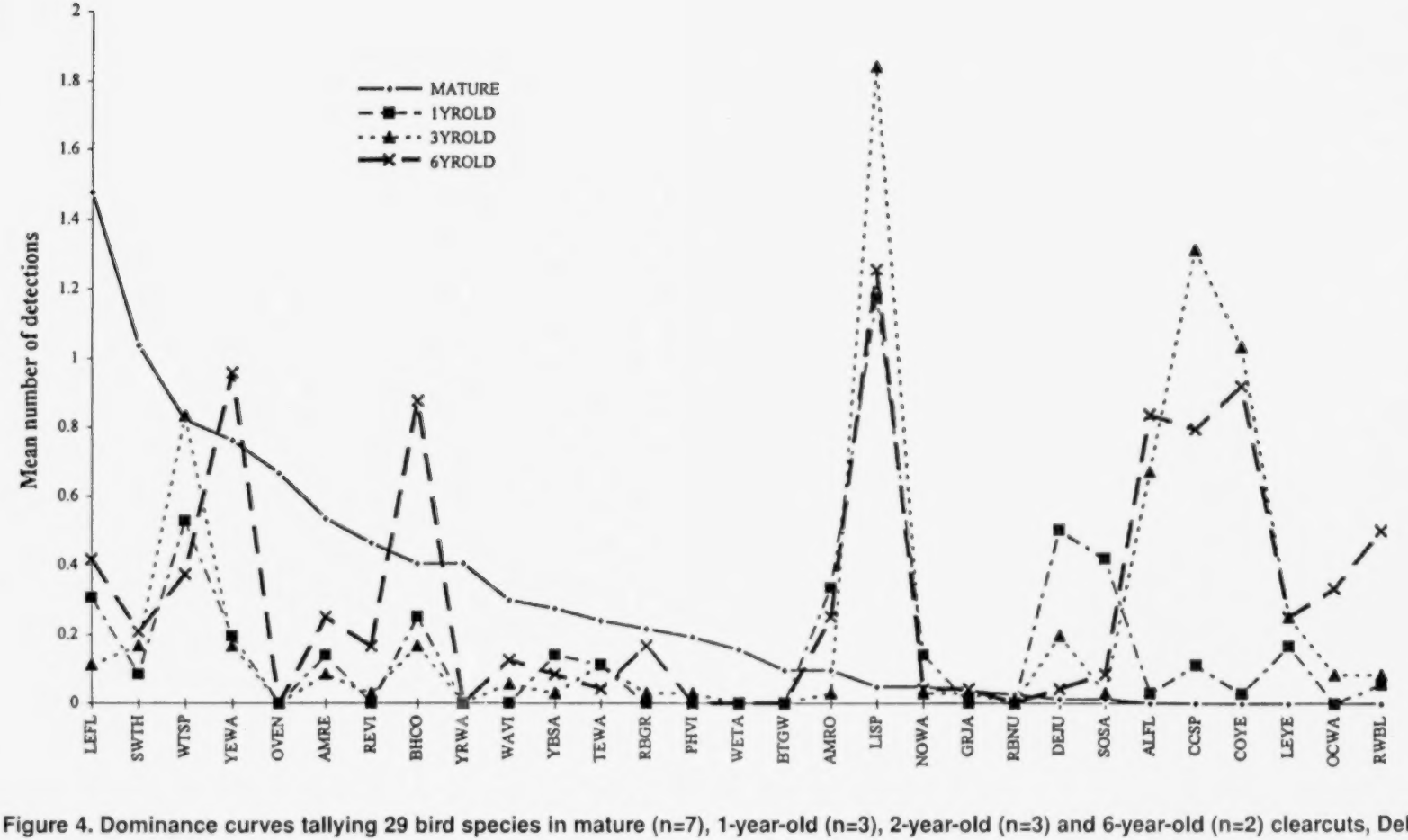

Figure 4. Dominance curves tallying 29 bird species in mature (n=7), 1-year-old (n=3), 2-year-old (n=3) and 6-year-old (n=2) clearcuts, Del Rio, 1997.

old cuts (four, five, and six years old). There were seven species for which a significant interaction between stand age and year was recorded (Table 22). Follow-up one-way ANOVAs using Duncan's multiple range tests to test for differences between stand ages within years indicated that these interactions were mainly due to the change in abundance of these species as the clearcuts aged (Table 22). In most cases, the older clearcuts had more detections than young clearcuts and/or mature stands. Species abundance in mature forests and young and old clearcuts for 1995 to 1999 is presented in Appendix C.

The abundance of Alder Flycatcher, Common Yellowthroat and Clay-colored Sparrow was significantly higher in older clearcuts than in younger clearcuts and mature stands in both 1995 and 1996 (Table 22). As the regenerating stands increased in age, they were colonized by these species. By 1997, when the younger clearcuts were three years old, Clay-colored Sparrow and Common Yellowthroat were significantly more abundant in any regenerating stands than in mature stands. In addition, both species were equally abundant in both young and old clearcuts. Abundance of Alder Flycatcher and Orange-crowned Warbler remained higher in older clearcuts than in younger clearcuts.

The significant stand-age and year interaction noted for Lesser Yellowlegs (Table 22) appears to be due to an overall increase in species abundance in both young and older clearcuts from 1995 to 1997. In 1995, this species was detected infrequently, and no significant difference in abundance was noted in any of the stand ages. In 1997, Lesser Yellowlegs was more abundant in both clearcut ages than in mature stands. Lincoln's Sparrow followed no trend. The significant differences between year and stand age for White-throated Sparrow is difficult to interpret (Table 22). This species's ability to breed in a wide variety of habitats likely confounded any obvious differences between stand age and year.

Although not tested for statistical significance, data from 1999 (see Appendix C) show patterns similar to 1995, 1996 and 1997.

Impact of Retention Patches in Harvested Stands—Field personnel noted that many species that were normally detected in mature stands were recorded in clearcuts in either patches of trees or lone trees that had been left standing after harvesting. In order to assess the role of these remnant habitat features, efforts were made during bird surveys in 1996 and 1997 to document any bird activity that took place in these retention patches. Of the over 60 species that were detected in clearcut blocks during surveys in 1996 and 1997, 11 were detected > 50% of the time in mature stands. In clearcuts, these species were detected > 61% of the time in either retention patches or retention trees (Table 23, Figure 5). It is apparent that retention patches are attractive to species typically associated with mature aspen stands, although no confirmation was made whether breeding occurred or was successful in retention patches. It was also noted that Dark-eyed Junco and Lincoln's Sparrow were recorded frequently in or around slash piles in young clearcuts. Black-throated Green Warbler was most often detected in mature aspen stands with a component of spruce.

5.2 Forest Songbirds in Mature Mixed-wood Stands

5.2.1 Diversity and abundance

Bird Richness and Abundance—Forty-four species were detected during surveys in the five mixed-wood stands, and a further four species were recorded outside the survey periods. In the three deciduous-leading stands, 37 species were detected on surveys whereas 32 species were detected in the two conifer-leading stands (Appendix D). The total number of detections during the survey was 471. The mean number of detections per survey was similar in both the deciduous-leading (i.e., 8.77) and coniferous-leading stands (i.e., 8.28).

Dominant Species—Five species accounted for over 50% of the detections in mixed-wood surveys: Yellow-rumped Warbler, Swainson's Thrush, Black-throated Green Warbler, Warbling Vireo and Dark-eyed Junco. The 10 most common species in the deciduous- and coniferous-leading stands are presented in Table 24.

Rare and Endangered Species—The two rare and endangered species encountered during the mixed-wood forest surveys included Black-throated Green Warbler (blue-listed) and Philadelphia Vireo (blue-listed). Black-throated Green Warbler was particularly common, being encountered 36 times (i.e., 7.6% of all detections), and was in the top four most common bird species in both deciduous-leading and coniferous-leading forests (see Table 25). Philadelphia Vireo was encountered only once during the survey in a

deciduous-leading stand.

Mature Aspen versus Mature Mixed-wood Stands—Although data for total abundance and species richness are not comparable between the long-term study in mature aspen and the reconnaissance-level study within mixed-wood forests, some interesting differences can be noted. The 10 most commonly detected species within mature aspen stands at Del Rio and Tate Creek are quite different from those in mixed-wood stands (Table 25).

Eight of the 10 most commonly detected species in the mixed-wood stands were also found at both Tate Creek and Del Rio. In comparison, the mixed-wood stands shared only four species with Del Rio and four species with Tate Creek. Warbling Vireo, Swainson's Thrush and White-throated Sparrow were in the top 10 most common species in all of the three study areas. Common species in mixed-wood stands, such as Black-throated Green Warbler, Pine Siskin and Golden-crowned Kinglet, were found at very low densities in mature aspen stands at Del Rio and Tate Creek.

Several species were unique to mature aspen stands and others were unique to mixed-wood stands (Table 26). The list of species unique to mature aspen stands was, as expected, much longer than that of mature mixed-wood stands because of the intensive survey activity in mature aspen stands.

5.3 Forest Owls in Aspen and Mixed-wood Stands

5.3.1 Aspen stands

Owl Detections—Only two owl species, Great Gray Owl and Great Horned Owl, were detected in the Del Rio area. Over the survey period, six Great Gray and four Great Horned owls were detected, which resulted in a detection rate of 0.05 Great Gray Owl/calling-station night and 0.03 Great Horned Owl/calling-station night (Table 27). Based on the spacing of the calls and simultaneous calling in some cases, these results likely represent four Great Gray Owl and three Great Horned Owl territories.

A pair of Great Gray owls nested adjacent to Control Block C2 at the Del Rio study area in 1999 and was seen on a regular basis (Phinney and Lance 1999). Merkens and Booth (1996) observed one adult Great Gray Owl and three juveniles during breeding bird surveys in Del Rio in 1995.

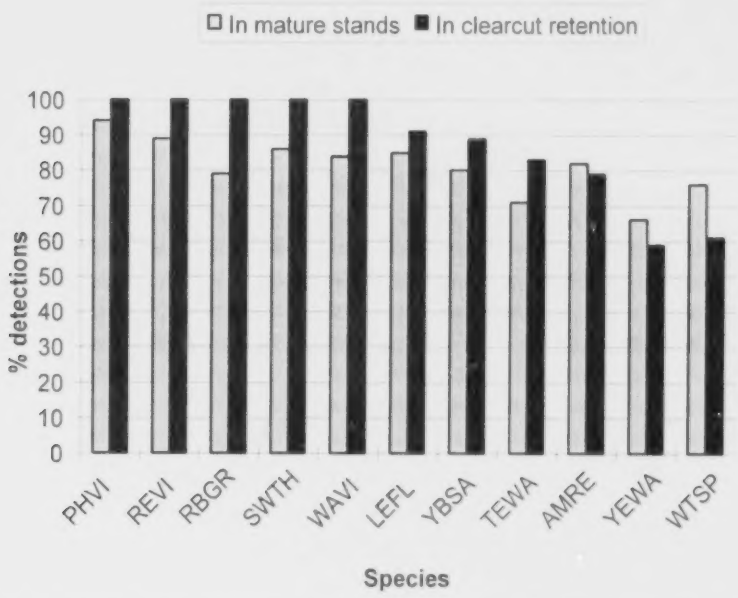

Figure 5. Percent of observations of birds that appear to prefer mature stands that were observed in mature stands and percent that were observed in retention patches within clearcuts, Del Rio, 1996-1997.

Habitat Associations—Accurate estimation of the habitats that owls associate with is dependent on the accuracy of the estimation of distance to calling owls. As the distance to calling owls increases, the reliability of placing owls in the correct forest cover polygon decreases, particularly if polygons are small and irregularly shaped. As a result, the following owl/habitat associations should be interpreted with caution.

Great Gray Owl detections were clustered in and adjacent to a wet, tamarack/black spruce bog area (five of six locations). Of these five detections, one occurred within the bog (i.e., larch/black spruce/aspen forest cover type), and four occurred in mature aspen polygons (Table 28) in close proximity (50-350 m) to the wet, tamarack/black spruce area.

The four Great Horned Owl detection locations were in three different geographic areas within the Del Rio area. One of the sites was within the larch/black spruce area, a second site was in or near a swampy area in the extreme southwest of the study area, and a third site was in mature aspen stands in the northeast section of the study area.

Several incidental daytime observations (i.e., not during playback surveys) were made. Great Gray owls were seen foraging on three occasions, and another was heard. Two of the foraging observations occurred within the same five-year-old clearcut. The owl was seen perched on regenerating aspen and residual white spruce within the cutblock and on mature aspen along the edge. Foraging took place primarily in the centre of the cutblock (>100 m from the edge), but included some foraging attempts from trees on the forest edge. A third foraging observation was of an individual perched along the roadside adjacent to a mature aspen stand. Another individual was heard calling from a mature aspen stand immediately adjacent to a wet area.

5.3.2 Mixed-wood stands

Owl Detections—Three owl species, Barred, Great Horned and Northern Saw-whet, were detected in mixed-wood sites. Detection rates were 0.18 detections/calling-station night for Barred Owl, 0.13 detections/calling-station night for Great Horned Owl and 0.01 detections/calling-station night for Northern Saw-whet Owl (Table 29). Six detections of Great Horned Owl in the Boudreau Lake area likely represented two pairs. At Murray River, three detections of Great Horned Owl likely represented two pairs, and nine detections of Barred Owl appeared to represent four pairs. Along the A1 Road, three Barred Owl detections appeared to represent two pairs (see Booth and Harrison 1997 for justification of number of territories).

Habitat Associations—Most of the Great Horned Owl detections in mixed-wood forests occurred in mature stands, with only one detection occurring in a forest aged 41-60 years. Great Horned Owl also occurred in a wide variety of stand types, including mature aspen, lodgepole pine/cottonwood/spruce, and spruce/aspen with a minor component of cottonwood (Table 30). Barred Owl was most often detected in mature stands, with only one detection in a 41- to 60-year-old stand and two detections in 61- to 80-year-old stands. Barred Owl was also detected in a wide variety of stand types. The only Northern Saw-whet Owl was detected in a mature aspen/minor cottonwood/spruce stand.

5.4 Security Cover

Security cover data from surveys in mature and harvested aspen stands are presented in Merkens and Booth (1998a). Ground-level security cover in harvested blocks increased with stand age. Vegetation, woody debris and topography totally (or nearly totally) obscured the survey card at >= 2 m from the observer in two-, three - and six-year-old stands. Percent ground-level cover in one-year-old cuts ranged from about 50% to 90% at increasing distances between observer and survey card, while in mature stands it ranged from 40% to 95%.

With the observer's eye at one metre above ground level, percent cover of the card decreased with increasing card height and increased with increasing stand age. That is, percent cover of the card at a height of two metres in one-year-old stands was the least (< 10%), while percent cover of the card at ground level in six-year-old stands was greatest (100%). Percent cover in regenerating stands increased as the card was moved away from the observer. Percent cover in mature stands decreased as the card was moved away from the observer. The reader is referred to Merkens and Booth (1998a) for full results.

5.5 Vegetation

Merkens and Booth (1998a) summarized species richness and percent cover of vascular plants in mature and harvested blocks. Incidence of herb and shrub

species differed between harvested blocks (< 6 years old) and mature stands, with some common mature-forest species uncommon in harvested blocks, and vice versa. Fewer than five herb or shrub species were found exclusively within mature or harvested stands. All shrub species found in mature stands were present at some level in the harvested stands. The number of species in herb, shrub and tree layers varied significantly with stand age. Generally, there were fewer herb species in mature and one-year-old stands and fewer shrub species in mature stands. Percent cover of herbs and shrubs 0-1 m tall was higher than other strata. Percent cover of herbs was reduced by about 50% immediately following harvesting, rebounded three years after harvesting and surpassed the original (mature forest) value six years after harvesting. Percent cover of grasses, a major component of the herb layer, dropped immediately following harvest (from 15% to 5%) and increased above pre-harvest conditions from three to six years after harvest (22-38%). Percent cover of shrubs 0-1 m tall was reduced by nearly 50% following harvesting, but the differences were not statistically significant. Shrub cover 1-2 m tall rebounded to original levels by three years after harvest. Aspen suckers dominated the 2-5 m shrub layer, providing 85-100% of cover in three-, five, and six-year-old harvested blocks. Details are presented in Merkens and Booth (1998a).

5.6 Small Mammals

5.6.1 Species richness

Eight rodent species, two carnivore species and unidentified insectivore species (shrews) were captured in mature and harvested study blocks in Del Rio and Tate Creek during 1992–1997 (see Appendix E and F for scientific names and codes). Deer Mouse, Red-backed Vole and Meadow Vole were the predominant species and were captured in all blocks and all stand ages. Red Squirrel and Northern Flying Squirrel were both captured in mature stands only, the latter only at the Tate Creek site. Marten were captured in mature stands and in a large retention patch in one study block. Meadow Jumping Mouse, Least Chipmunk, and Ermine were captured relatively rarely, and exclusively in harvested blocks. Shrews were captured in all blocks.

5.6.2 Effects of harvesting on small mammal richness

Merkens and Booth (1998a) found no significant difference in species richness of small mammals among seven mature and five harvested blocks during 1995-1997. However, species richness was significantly lower in mature and harvested blocks in 1996 compared to 1995 and 1997 (repeated-measures ANOVA and follow-up t-tests: Merkens and Booth 1998a).

5.6.3 Species abundance in mature stands

Significant annual differences in abundance of Deer Mouse, Red-backed Vole and Meadow Vole in seven mature stands were observed (repeated-measures ANOVA: Merkens and Booth 1998a). Springtime populations (as represented by captures per 100 trap-nights) of all three species were low in 1993, increased to 1995 and declined to 1996 (Figure 6). Fall populations of Deer Mouse were moderate in 1993, higher in 1994-1995, crashed in 1996 and rose to near the 1993 level in 1997. Between-year population fluctuations were also evident in fall captures of Red-backed Vole and Meadow Vole, with a similar population crash in 1996. The winter of 1995-1996 was particularly long and harsh, with significant snowfall accumulation for the region.

5.6.4 Effects of harvesting on small mammal abundance

Using repeated-measures ANOVA and data from mature and harvested blocks in 1995-1997, Deer Mouse was found to be consistently more abundant in mature stands than in young or old cutblocks (one- to three-year-old and four- to six-year-old, respectively). This was primarily due to relatively high capture rates on mature blocks during spring 1996 (follow-up one-way ANOVA and Duncan's Multiple Range test: Merkens and Booth 1998a). Abundance of Red-backed Vole and Meadow Vole did not differ among the stand ages.

5.6.5 Effects of stand age on small mammal abundance (1997)

Using repeated-measures ANOVA and the 1997 individual trapping session data for seven mature blocks

and two six-year-old, three three-year-old and three one-year-old harvested blocks, Merkens and Booth (1998a) found Deer Mouse was significantly more abundant in one-year-old harvested blocks than any other stand age (follow-up one-way ANOVA and Duncan's Multiple Range test). Abundance of Meadow Vole was more variable than abundance of Deer Mouse, and no significant stand-age differences were found. There were no significant differences in Red-backed Vole abundance among stand ages. In 1997, 27 shrews were captured, 39% of all shrew captures. Twenty-four of the 27 were in harvested study blocks.

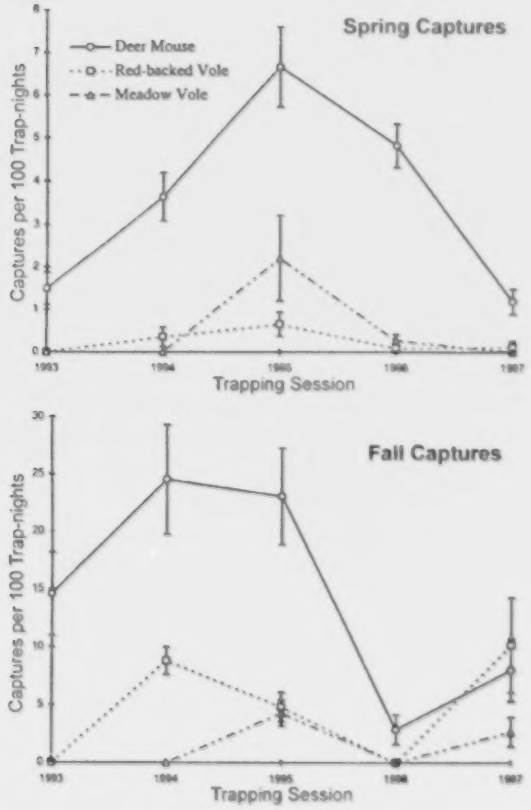

Figure 6. Abundance of three small mammal species captured in mature blocks, Del Rio, 1993–1997.

6 DISCUSSION

6.1 Forest Birds

Eighty-two bird species were documented in the mature and harvested study blocks at Del Rio and Tate Creek from 1992 to 1999. Lance et al. (1996) reported 102 species in the Dawson Creek Forest District in two years of surveys that included shrub and pole-sapling stages of aspen regeneration (and other forest types of the district) and 63 species in a study of birds in successional aspen forests in west-central British Columbia. Lance and Phinney (1996a) tallied 100 species during four years of surveys in regenerating aspen stands in the Dawson Creek Forest District, 48 of which occurred at least once in mature stands. A study in five age classes of aspen forests of Alberta tallied 54 species (Westworth and Telfer 1993), while 55 breeding species were observed in three successional stages of aspen-dominated boreal mixed-wood forests in Alberta (Schieck et al. 1995). Bird species diversity is high in the northeastern portion of British Columbia relative to other boreal mixed-wood and aspen areas. There are three likely reasons why our tally is lower than that of Lance and Phinney (1996a): they sampled substantially older regeneration than we did, many of their regenerating study blocks had significant structural diversity because they originated from fires, and many of their stands contained significant portions of edge habitats. In addition, their species list included all observations in the district.

6.1.1 Mature aspen stands

Annual differences in abundance—Significant annual differences in the abundance of several bird species were noted in mature stands at the Del Rio study area between 1993 and 1997 (Merkens and Booth 1998a). For many species at Del Rio, 1994 represented a low in bird abundance compared to other years (Table 12; Figure 3). Some of these species, such as American Redstart, Brown-headed Cowbird, Least Flycatcher, Ovenbird, Philadelphia Vireo, Rose-breasted Grosbeak, Red-eyed Vireo, Swainson's Thrush, Tennessee Warbler and Yellow Warbler, are insectivorous neotropical migrants (Ehrlich et al. 1988).

Annual variations in forest birds have been reported by numerous authors (Holmes et al. 1986, Virkkala 1991, Blake et al. 1994, Haila et al. 1994, Kirk et al. 1997) and have been attributed to five potential causal factors: 1) food supply, especially defoliating Lepidoptera (Holmes et al. 1996); 2) poor spring weather conditions (Blake et al. 1994, Pojar 1995, Holmes et al. 1996); 3) forest successional changes (Blake et al. 1994, Kirk et al. 1997); 4) competitive interactions (Holmes et al. 1996); and 5) non-breeding mortality (Holmes et al. 1986). Habitat alteration on wintering habitats has also been attributed to changes in the abundance of neotropical migrant species (Robbins et al. 1989, Kirk et al. 1997).

Although speculative, the low overall abundance of birds in Del Rio in 1994 suggests that the availability of food, or the combination of lack of food and poor springtime weather, may have caused the lower abundance. Further, since these species were recorded frequently in following years, the low abundance of birds observed in 1994 was likely part of a normal population fluctuation rather than a long-term trend toward population decline. A similar trend in bird abundance across years at Tate Creek and Del Rio suggests that the low abundance of birds observed in 1994 may have occurred in other areas of the Peace River lowlands. However, a nearby study of bird fauna in aspen stands near Dawson Creek (Lance and Phinney 1996a) found an overall low abundance of birds in 1993 and 1995, unlike the annual variations observed at Del Rio and Tate Creek. These observations correspond with the observation that patterns of variations in abundance are generally non-uniform, even within regions (James et al. 1992).

Rare and endangered species—The Philadelphia Vireo, which is blue-listed in British Columbia, was observed 92 times during 1992-1999. It was one of the 15 most common species reported at Del Rio, and its abundance did not vary significantly during 1993-1997. It was observed in mature stands all but once, when it was reported in a retention patch in a young clearcut. Similarly, Lance and Phinney (1994) reported Philadelphia Vireo only in mature aspen stands in the Dawson Creek Forest District, and Savignac (1998) found them in mature mixed spruce-aspen and mature aspen stands near Fort Nelson. Generally, it is a species found in open mixed deciduous forests and/or young regenerating deciduous forests (Salt and Salt 1976, DeGraaf et al. 1991, Semenchuk 1992, Enns and Siddle 1996). However, in northeastern British Columbia its habitat includes mixed deciduous forest, deciduous thickets adjacent to coniferous forest, and occasionally mature and old-growth aspen or mixed-wood forest (Cooper et al. 1997a). The regenerating cutblocks of our study may not have reached the level of structural development suitable for Philadelphia Vireo.

The blue-listed Black-throated Green Warbler was observed 52 times at Del Rio and Tate Creek during 1992-1999, andonly in mature aspen stands where patches of conifers were present. This warbler is most often associated with mature coniferous and mixed-wood stands in the boreal forest (Salt and Salt 1976, Campbell et al. 2001, Cooper et al. 1997b, Siddle 1991, Semenchuk 1992, Enns and Siddle 1996, Lance and Phinney 1996b), especially mature riparian stands (Cooper et al. 1997b). However, it is also reported in mature deciduous forests (Salt and Salt 1976, DeGraaf et al. 1991, Siddle 1991, Semenchuk 1992, Westworth and Telfer 1993, Enns and Siddle 1996, Savignac 1998). Enns and Siddle (1996) proposed mixed white spruce and poplar with a mid-canopy understorey of aspen as a habitat model for Black-throated Green Warblers. As in other studies near Dawson Creek (Booth and Merkens 2001, Phinney pers. comm.), there was no clear association of this species with riparian habitat in the vicinity of the Del Rio or Tate Creek study areas (Merkens and Booth 1998a). Use of harvested or regenerating stands is not documented in the literature.

Connecticut Warbler, a red-listed species, was recorded 21 times in Del Rio and Tate Creek during 1992-1999 in mature aspen forests, harvested cutblocks immediately adjacent to mature aspen stands, and along the edge of a seismic line through mature aspen. This species has been consistently found in mature aspen and aspen-dominated stands in northeastern British Columbia that resemble our study areas (Siddle 1991, Lance and Phinney 1994, 1996a, Enns and Siddle 1996). It has also been found in a variety of habitats (Semenchuk 1992, DeGraaf et al. 1991), including, in British Columbia, mixed Balsam Poplar and White Spruce (Cooper et al. 1997c), pole-stage aspen regeneration (Lance and Phinney 1996a) and at low densities in 40- to 60-year-old aspen stands (Savignac 1998). Westworth and Telfer (1993) did not record Connecticut Warbler on one- and two-year-old aspen clearcuts but determined that their presence in aspen stands older than 30 years was related to canopy cover.

6.1.2 Harvested aspen stands

Effects on diversity and abundance—Clearcutting of mature stands at Del Rio and Tate Creek resulted in significant changes in the abundance of many bird species (Tables 12 and 16). Changes were also noted as clearcuts aged (Table 13, Figure 2), with the lowest abundance of birds recorded in young clearcuts and then increasing with clearcut age. Changes in bird species abundance as a result of forest harvesting and subsequent regeneration have been observed in forests throughout the world (Conner and Adkisson 1975, Monkkonen and Helle 1990, Johns 1993, Farr 1993, Litvaitis 1993, Yahner 1993, Lent and Capen 1995, Pojar 1995, Kirk et al. 1996, Shieck and Nietfeld 1996).

Although reduced species richness was evident at Del Rio in young clearcuts (Table 17) species richness was higher in older clearcuts (i.e., > three years) than in mature blocks. A similar response was noted in aspen forests in the Prince Rupert Forest Region (Pojar 1995) and in clearcuts of mixed oak stands in Virginia where overall bird abundance was lowest in one-year-old clearcuts and highest in three- to 12-year-old clearcuts (Conner and Adkisson 1975). Webb et al. (1977) also found the number of species higher on all logged areas than in undisturbed areas in hardwood forests in the Adirondack Mountains of New York (although Noon et al. [1979] discuss the potential shortfalls and assumptions of Webb's analysis). In contrast, Lance and Phinney (1996a) found higher diversity and abundance of songbirds in mature aspen stands than recently cut stands (4-7 years old, equivalent to older clearcuts in this study) and shrub and pole sapling stages in the Dawson Creek Forest District. Similarly, near Fort Nelson, Savignac (1998) reported higher density and abundance in mature aspen stands than regenerating stands >20 years old.

The higher species richness we observed in older clearcuts may be a result of higher habitat heterogeneity than in younger clearcuts, especially as it pertains to forest edge, retention patches, exposed areas of open water and open ground and dense shrubby habitat. Avian species diversity in forest habitats has been correlated with diversity of height of vegetation and degree of stratification (MacArthur and MacArthur 1961), habitat features found in older clearcuts at Del Rio. However, when a harvested stand reaches the pole sapling stage of regeneration (beyond the time frame of this report), there is lower stand diversity, which Hobson and Bayne (2000) linked to lower bird species diversity in their study of 15- to 25-year-old clearcuts, mature (50- to 60-year-old) stands and old (80- to 110-year-old) aspen-dominated forests regenerated from fire.

Increased abundance after harvesting—Harvesting of mature stands provides habitat for bird species adapted to the open forest canopy, sparse understory and exposed mineral soils that clearcutting often creates (Kricher 1973, Morgan and Freedman 1986, Farr 1993, Welsh 1993, Westworth and Telfer 1993, Pojar 1995). At Del Rio, an immediate colonization of clearcuts by Dark-eyed Junco was noted the first year after harvesting. Dark-eyed Junco was the only species that was detected significantly more often in young clearcuts than in either old clearcuts or mature blocks, consistent with its preference for open stands (Freedman et al. 1981). Juncos were often detected near to or within slash piles. The presence of this structural attribute likely made new clearcuts at Del Rio particularly attractive for Dark-eyed Junco (Morgan and Freedman 1986).

Several species (i.e., Lincoln's Sparrow, Clay-colored Sparrow and Common Yellowthroat) also showed a strong preference for young clearcuts, but only once the clearcuts were two or more years old. The delay in colonization by these species is likely related to the emergence of shrubs in younger stands by age two and three and is consistent with the findings of Freedman et al. (1981), Westworth and Telfer (1993) and Kirk et al. (1996). Both Clay-colored Sparrow and Common Yellowthroat nest in low shrubs (Ehrlich et al. 1988), and Lincoln's Sparrow, although being a ground nester and ground gleaner (Ehrlich et al. 1988), also has a tendency to be associated with patches of dense shrubby vegetation (Westworth and Telfer 1993). Westworth and Telfer (1993) found that Chipping, Clay-colored, Le Conte's, Lincoln's and White-throated sparrows dominated young clearcut communities, but only Le Conte's was restricted to clearcuts. Schieck and Hobson (2000) found that Clay-colored, Le Conte's and Song sparrows were common two years following harvesting in mixed-wood stands in northern Alberta, but decreased in abundance as clearcuts aged. Kirk et al. (1996) found Le Conte's and Song sparrows to be most abundant in clearcuts less than 10 years old. Le Conte's Sparrow, a blue-listed species in British Columbia, was observed six times in five- and eight-year-old clearcuts at Del Rio in 1999. Apparently, the low canopy cover and high density of regenerating aspen are attractive to Le Conte's Sparrow.

Alder Flycatcher and Orange-crowned Warbler appear to be associated with the development of taller shrubs (two to five metres) at Del Rio, as both species were detected more often in older clearcuts (e.g., six-year-old) than in younger clearcuts. These observations are consistent with their utilization of tall shrubs for nesting (Alder Flycatcher) and foraging (Orange-crowned Warbler) (Ehrlich et al. 1988, Pojar 1995, Kirk et al. 1996).

Decreased abundance after harvesting—Several species of birds were absent from clearcuts or were detected in significantly lower abundance in clearcuts than in mature stands (Table 16). Many of these species rely on habitat features that are present in mid-successional or older stands. Red-eyed Vireo tends to be closely associated with a deciduous overstory (Anderson and Shugart 1974, Flack 1976, Freedman et al. 1981, Ambuel and Temple 1983, Pojar 1995, Kirk et al. 1996), and species such as Warbling Vireo, Swainson's Thrush and Yellow-rumped Warbler have been linked with tall shrubs and deciduous cover at mid-canopy heights (DeByle 1981, Scott and Crouch 1988a, Westworth and Telfer 1993, Pojar 1995). Philadelphia Vireo has been found to be associated with the dense canopy of mid-successional stands 15-20 years old (Schieck and Nietfeld 1996, Kirk et al. 1996), and Ovenbird has been associated with a high percentage of canopy cover, low percentage of ground cover, low density of shrubs, high basal area of deciduous trees, low basal area of conifers, and deep layer of leaf litter (Thompson and Capen 1988, Robbins et al. 1989, Westworth and Telfer 1993, Schieck and Nietfeld 1996).

The Ovenbird is of particular interest as a species that decreased in abundance after harvesting because it prefers interior forest habitats. At the Del Rio study area, the Ovenbird was common in mature aspen forests (Table 16) but was never seen in new or old clearcuts. It may be unaffected by low-intensity logging (e.g., 25% of crown removed in selective-logging scenarios), but its abundance is reportedly diminished in heavily logged areas (Webb et al. 1977). Although it will recolonize and nest in regenerating clearcut habitats (> 10 years old; Yahner 1993), it is thought to be particularly sensitive to forest fragmentation, which reduces Ovenbird pairing success and reproductive success, primarily within a 200-m zone adjacent to clearcuts, by altering the dynamics of dispersal or the selection of habitat by females (Villard et al. 1993, King et al. 1996).

Black-throated Green Warbler and Red-breasted Nuthatch were recorded in low numbers in Del Rio and Tate Creek; except for one observation of a nuthatch at Tate Creek, neither species was recorded in clearcut stands. Use of deciduous forests and avoidance of clearcuts has also been recorded for the Black-throated Green Warbler in Nova Scotia (Freedman et al. 1981). Reductions in abundance of the Black-throated Green Warbler in heavily logged areas has been documented, although abundance may be unaffected by low-intensity logging (partial crown removal) (Webb et al. 1997). Abundance of Black-throated Green Warbler and Red-breasted Nuthatch was higher at Tate Creek, where spruce is a more dominant feature in mature stands. Both species have a strong affinity for a coniferous tree component (Westworth and Telfer 1993, Schieck and Nietfeld 1996, Schieck and Hobson 2000), a habitat feature not well developed at Del Rio.

Role of retention patches—Many species were found consistently in both mature stands and clearcuts during the study. In most cases, these species were detected in either retention patches or trees left deliberately after harvesting (Table 23). An example of this is Least Flycatcher, a species typically associated with mature stands (Webb et al. 1977, Pojar 1995, Schieck and Nietfeld 1996) or stands with a relatively dense canopy (Kirk et al. 1996), but found at Del Rio in similar abundance in mature, young and old clearcuts. Of Least Flycatcher detections in clearcuts, 91% were in either retention trees or patches, illustrating the importance of retaining mature forest attributes within a clearcut for some species. This finding differs from Freedman et al. (1981) who found that Least Flycatcher was common within mature deciduous forest, thinned forest and strip-cut areas, but never on clearcuts. Other species typically associated with mature forests but also found on cutblocks with retention patches or trees during our study include: Red-eyed Vireo, Rose-breasted Grosbeak, Swainson's Thrush, Warbling Vireo, Yellow-bellied Sapsucker, Tennessee Warbler and American Redstart. One sighting of Philadelphia Vireo in a cutblock was also within a retention patch.

Retention of specific habitat components can play an important role in maintaining and enhancing species richness and abundance. For example, Schreiber and deCalesta (1992) found that species richness and density of cavity-nesting birds were positively correlated with snag density on clearcuts in western Oregon. A similar correlation has been observed in other areas of

North America (Dickson et al.1983, Raphael and White 1984, Zarnowitz and Manuwal 1985). Merrill et al. (1998) conducted an extensive study of the effects of leaving residual patches within clearcuts in aspen forests in northern Minnesota, concluding that the patches contributed to forest-bird diversity and possibly enhanced bird populations on regional and landscape scales. Species that exhibited a significant association with residual patches in the Minnesota study included Least Flycatcher, Ovenbird, Black-throated Green Warbler and Rose-breasted Grosbeak, while species such as Mourning Warbler, Alder Flycatcher and Song Sparrow were strongly associated with clearcuts without residual patches. Although the presence of typically forest-breeding songbirds in residual patches does not necessarily indicate breeding, anecdotal observations of nests within these patches by Merrill et al. (1998) suggest that residual patches may be good habitat for at least some species. The presence of retention patches in clearcuts at Del Rio likely contributed to higher species richness in harvested blocks. This was clearly illustrated in one of the new clearcuts (DM) where numerous species were recorded within a large linear retention patch that was connected with the intact forest. Clearcuts at Del Rio, therefore, often contained species associated with early successional stages and, because of the influence of retention patches, species normally detected in mature stands.

6.1.3 Mature mixed-wood stands

Species composition of the most common birds in mature mixed-wood forests of the Murray River study area (Booth 1996) was very different from that of mature aspen forests at Del Rio and Tate Creek. Species such as Black-throated Green Warbler, Pine Siskin, Red-breasted Nuthatch and Golden-crowned Kinglet that were common in mixed-wood stands were found at very low densities in mature aspen stands. Similar findings were recorded in Alberta, where Schieck and Hobson (2000) found the highest densities of Red-breasted Nuthatch, Golden-crowned Kinglet, Swainson's Thrush, Black-throated Green Warbler and Pine Siskin in forests with large white spruce trees. Black-throated Green Warbler, which is blue-listed in British Columbia, was also found in mixed coniferous stands in northeastern British Columbia by Savignac (1998) near Fort Nelson, Setterington and Boulanger (2000) in the Halfway River watershed and Booth and Merkens (2001) near Tumbler Ridge.

Mixed-wood forests in the boreal forest are considered to contain the richest habitat for birds (Wedeles and Van Damme 1995). Pojar (1995) found that mixed stands in the Prince Rupert Forest District contained significantly more species and greater bird numbers than mature and old aspen stands. Schieck et al. (1995) found that coniferous-dependent species were more abundant in old than in mature or young aspen forests, likely because old aspen forests had a higher conifer composition than younger forests. Cumming et al. (1994) conducted a simulation model, investigating the relationship between planned logging operations and their effect on wildlife. They predicted that conversion of mixed-wood stands to production of single species would result in serious impacts to species dependent upon mature and old stands of aspen, white spruce or mixed-wood. Our pilot surveys in the mixed-wood forests in the Dawson Creek area were not subsequently funded; however, other concurrent or later studies in northeastern British Columbia have included songbird surveys in mixed-wood forests (Lance and Phinney 1996b, Bennett and Enns 1996, Bennett 1998, Savignac 1998).

6.2 Forest Owls in Aspen and Mixed-wood Stands

Booth and Harrison (1997) detected four species of owls in the aspen and mixed-wood forests in northeastern British Columbia: Great Gray, Great Horned, Northern Saw-whet and Barred. Boreal Owl was expected but not observed during the surveys.

The presence of Great Gray Owl was anticipated in the Del Rio area because of previous sightings and the presence of a large tamarack/black spruce bog. Other studies in the boreal forest have found an association of Great Gray Owl with these bogs (Harris 1984b, Servos 1987, Spreyer 1987). Great Gray owls were observed foraging in open habitats (e.g., cutblocks) during the study. Foraging in open habitats has also been reported by Nero (1980) and Mikkola (1983) and is due to the presence and availability of microtine rodents, a primary food source for Great Gray Owl (Duncan 1987, Osborne 1987, Servos 1987, Hayward 1994). Forest harvesting in many areas appears to have increased the food supply for Great Gray Owl (Hayward 1994), although this was not observed in the Del Rio area (Booth and Merkens 1997). The absence of Great Gray

Owl in mixed-wood stands during the study may be due to the absence, with one exception, of tamarack/black spruce areas in sampled mixed-wood stands.

Great Horned Owl was located in a variety of habitats during the survey, which is consistent with the wide range of habitats utilized in other areas of North America (Johnsgard 1988, Bosakowski et al. 1989, Morrell and Jahner 1995).

Barred Owl was detected in a variety of habitat types and stand ages in mixed-wood areas surveyed but was absent from the more homogeneously deciduous Del Rio area. Because Barred Owl is considered to be a food generalist, consuming a wide variety of prey species (Bosakowski et al. 1987, Johnsgard 1988), it is uncertain why they were not recorded at Del Rio. Barred Owl may avoid areas where Great Horned Owl is present (Fuller et al. 1974), but other studies (Forsman and Booth 1986) and this study have recorded both species living in close proximity. Their absence at Del Rio may be due to their preference for mixed-wood forests (Johnsgard 1988, Campbell et al. 1990), which is perhaps related to nest-site preferences and subsequent nest-site availability. Barred Owl often nests in broken tops of large conifers or in natural cavities of large-diameter deciduous trees such as cottonwood (Campbell et al. 1990, Mazur et al. 1997, Postupalsky et al. 1997). The rare occurrence of these trees at Del Rio may have precluded Barred Owl from this area.

Northern Saw-whet Owl was recorded only once during the survey. Northern Saw-whet Owl is known to inhabit a variety of habitats (Campbell et al. 1990, Cannings 1993) and was expected to occur within the survey area in greater abundance than was recorded. A factor that may limit occurrence of Saw-whets at Del Rio is the limited availability of larger woodpecker cavities, particularly those of Northern Flicker. Northern Flicker is uncommon in the Del Rio area, and no active nests have been located in the area (Darling and Farr 1994, Merkens and Booth 1997).

6.3 Security Cover and Vegetation

We documented a substantial change in vegetation structure and diversity from mature aspen stands through early stages of regeneration (Merkens and Booth 1998a), similar to that documented by Lee et al. (1995), Crouch (1983), Westworth and Telfer (1993), Pojar (1995) and Morgan and Freeman (1996).

With the change in vegetation come beneficial and detrimental changes in wildlife habitat values. Clearcutting resulted in reductions and gains of particular forest characteristics (e.g., percent canopy cover, density of stems or low and tall shrubs) which in turn increased or reduced the value of the site to various bird and small mammal species. As a result of removing the merchantable mature aspen trees, there was increased growth of herb and woody stems on the blocks (particularly aspen suckers), which provide ground-level and low-level security cover for wildlife. We found it more difficult to detect an object in the thick low-level vegetation on cutblocks than in mature stands, which were more open above one-metre height. We can expect increased or reduced use of the harvested blocks by some wildlife as the density, height and character of this low cover increases. The reader is directed to Merkens and Booth (1998a) for further discussion. Analysis of correlations and associations between changes observed in wildlife diversity and changes in forest structure and plant diversity have not been completed (see Future Research).

6.4 Small Mammals

6.4.1 Mature and harvested aspen stands

Our data on changes in vegetation indicate that clearcutting and partial cutting of aspen stands resulted in significant modification of small mammal habitats. Loss of large trees with relatively high canopies and temporary as well as moderately long-term alteration of the lower vegetation strata undoubtedly impact small mammals. Post-harvest microhabitat conditions at ground level are likely affected over the long term as low vegetation strata flush during the sapling stage. Changes in forage availability, ground moisture and security cover all impact small mammal habitat structure.

Previous studies of small mammal community responses to clearcutting have provided varying results. In his review of studies conducted in various forest types within North America, Kirkland (1990) determined that small mammals generally respond positively to conventional clearcutting. However, Probst and Rakstad (1987) found that harvesting in aspen forests temporarily reduces the number of small mammals for several years, and some species are much reduced in clearcuts and sapling stands. Much of the variation in small mammal community responses to clearcutting

can be explained by the forest type prior to harvest. There are subtle differences between coniferous and deciduous forests. These will be highlighted below as they relate to specific species and species groups.

Overall, species richness in the small mammal community changes little after clearcutting (Kirkland 1990, Probst and Rakstad 1987). This is not surprising, as forest species that are "lost" due to harvest are "replaced" in the arithmetic calculation of richness by other species that benefit from the altered landscape. During our study, we found no differences in small mammal species richness between mature stands and different-aged clearcuts. However, shifts in mammal species incidence (presence) did occur.

Decreased abundance after harvesting—Obviously, those species that require standing trees (for nesting and food sources) and the relatively complex vertical structure of mature or old growth forests will be most affected by clearcutting. Our data suggest that use of an area by Red Squirrel, Flying Squirrel and Marten likely decreases after aspen clear-cutting. This is based solely on the fact that these species were never captured within clearcut areas and that limited numbers were found within mature stands. Low capture success for sciurid species was expected given that trapping techniques employed by us did not target them. Low capture rates for Marten likely reflect low density within the areas surveyed. In some other studies, many tree dwelling sciurids (*Glaucomys* and *Tamiasciurus*) were found to decline in abundance after harvest of hardwood forests (Kirkland 1977, Kirkland 1990). The response of this group of species is likely affected by the intensity of the cut, the size of the cuts and the age at which the post-harvest populations were sampled. Although Marten will use a variety of forest ages throughout their geographical range, they tend to prefer relatively advanced successional stages (Harris 1984a). It is interesting to note that although Marten were never found within clearcuts during our study, their tracks were regularly recorded within one very large retention patch located in one of our cut-blocks.

Increased abundance after harvesting—In contrast to those species that reduce their use of an area after aspen harvest, Least Chipmunk and Meadow Jumping Mouse were found exclusively within clearcuts during our study, and Ermine except once. That is not to say that they did not use the mature stands, but rather that they were likely less abundant there. These observations are consistent with others reported in the literature (e.g., Hansson 1994), although most studies have not included Ermine captures in their results (see Kirkland 1990), and it is unclear whether they were captured during these other studies. In a study of successional stages, Roy et al. (1995) determined that ermine were associated with the relatively high percent grass cover found in stands 20-30 years old (Lee et al. 1995). Ermine may be attracted to aspen clearcuts in Del Rio where percent grass cover within clearcuts was low one year after harvesting and subsequently increased to levels significantly above those in mature stands (Merkens and Booth 1998a).

Chipmunks have been associated with forest edge habitat (Kirkland et al. 1985, Sullivan et al. 1999, Sullivan et al. 2000) and with shrub stage forests (Martell 1983, Harris 1984a) in many forested landscapes throughout North America. Seven of eight Least Chipmunk captures at Del Rio occurred in four-year-old clearcuts. Aspen clearcuts likely provide habitat suitable to the Least Chipmunk a few years after harvest, and the forest-clearcut interface provides an ecotonal transition that Chipmunks are able to exploit.

Meadow Jumping Mouse, as the name implies, is associated with higher levels of herbaceous or grass cover (Brower and Cade 1966, Monthey and Soutiere 1985, Roy et al. 1995). The two Jumping Mouse captures at Del Rio were in three- and five-year-old clearcuts; suitable low herb and grass habitat had sufficiently developed by then.

Shrews were not captured frequently (five-year total = 70), and numbers in 1996 and 1997 could be low because we discontinued pitfall trapping. In 1997 we captured 24 shrews in eight cutblocks of various ages and three shrews in six mature stands (Appendix E and F). The high capture rate in 1997 (39% of our total captures) is likely a random population fluctuation, but the ratio of captures in mature and harvested blocks suggests that shrews are attracted to harvested blocks. An increase in shrew abundance following harvesting is reported in other studies (Kirkland 1990). Shrews are particularly sensitive to moisture levels (Getz 1961) and may be controlled by moisture conditions at the microsite scale. Heavy dew within clearcuts as well as significant shading by a well-developed and vertically diverse shrub layer may provide conditions that are beneficial to these insectivores. Changes in the abundance of ground dwelling invertebrates associated with the breakdown of increased loads of dead material (both coarse woody

debris and annual loads of plant material) may also benefit shrews in clearcuts.

No change in abundance after harvesting—Three of the small mammal species captured during this study (Red-backed Vole, Meadow Vole and Deer Mouse) showed more subtle or no changes in response to aspen clearcutting. These species were found within all age classes and individually responded quite variably. It is likely that changes in vegetation at the microsite scale as opposed to stand level scales are responsible for many of the patterns we observed for these species. Given that we did not measure vegetation at the microsite scale, it is difficult to determine what factors are critical in affecting changes in the abundance of these species.

During our study, Red-backed Vole appeared to be unaffected by aspen clearcutting; however, their numbers were relatively low during most of our study. Despite its widely accepted association with mature forests (Merritt 1981, Martell 1983, Chan MacLeod 1995, Weaver 1995, Von Trebra et al. 1998, Sullivan et al. 1999), this species has responded positively to clearcutting in eastern hardwood forests (Kirkland 1990) and coniferous forests (Monthey and Soutiere 1985). During their study of small mammal communities in aspen stands, Probst and Rakstad (1987) found that Red-backed Vole initially declined after clearcutting. Red-backed Vole have specific habitat requirements: they respond to moisture levels (Getz 1968, Miller and Getz 1972, 1973), condition and abundance of coarse woody debris (Nordike and Buskirk 1991), dense cover (Wywialowsky and Smith 1988) and increased proportion of coniferous trees in mixed-wood sites (Roy et al. 1995). Merkens and Booth (1998b) assessed use of woody debris by Red-backed Vole in aspen and mixed-wood forests of the Dawson Creek Forest District. They found that networks of debris were used in mature and harvested sites, that voles tended to travel over or under debris rather than beside it and that debris diameter was not a determining factor of use (the amount of woody debris in a hardwood forest is substantially lower than in a softwood forest where larger debris pieces may be selected).

Meadow Vole did not appear to be significantly affected by aspen clearcutting in many of our stand age comparisons. In other studies, Meadow Vole numbers typically increased after clearcutting of hardwood forests (Kirkland 1990, Probst and Rakstad 1987, Monthey and Soutiere 1985). It should be noted that following the over-winter decline and breeding season depression in 1996, the increase in population of Meadow Vole was more prominent within cut areas in 1997, especially those that were older. The increase is likely a response to increased herb (especially grass species) cover that developed on cutblocks relative to conditions in mature stands. Meadow Vole respond positively to increase in grass cover in various forest types and stand ages, especially after forest harvest (Probst and Rakstad 1987, Monthey and Soutiere 1985).

In our comparison of mature stands and clearcuts between 1995 and 1997, it was apparent that Deer Mouse was negatively impacted by aspen harvest. Although Deer Mouse typically respond positively to clearcutting of coniferous forests (Hansson 1994, Chan MacLeod 1995, Weaver 1995, Von Trebra et al. 1998, Sullivan et al. 1999), there is some evidence that population levels in harvested aspen forests (Probst and Rakstad 1987) and newly cut hardwood forests (Kirkland 1990) are generally negatively affected. Kirkland (1990) suggests that this differential response of Deer Mouse in hardwood forests may be related to differences in the amount of post-harvest seedfall on the ground. Aspen stands typically do not produce vast amounts of seed because their main mode of reproduction is by the growth of suckers. However, we determined that Deer Mouse abundance in newly harvested blocks exceeded that of older clearcuts and mature stands in 1997, clearly in contrast to our multi-year results. These conflicting results indicate that post-harvest population change of Deer Mouse, although affected by forest type, must also be affected by other unmeasured underlying demographic or habitat parameters. We suspect that population dynamics across a multi-year time scale, pre-harvest population conditions and small mammal community structure within and surrounding the clearcut all may impact population responses of Deer Mouse (and other species) to clearcutting.

Cycles and stochastic factors—Abundance of individual small mammal species varied significantly over time. Typical annual cycles (low in spring, high in late summer-fall) were evident for most species we encountered. In addition, we measured significant variations in population size between years. Many microtine rodents are known for their regular multi-year population cycles in which widespread populations of individual species will peak every three to five years (Drost and Fellers 1991, Oli and Dobson 2001, Getz et al. 2000, 2001).

But some small mammal population fluctuations are random rather than cyclic (Gavsd and Howard 1981, Bowman et al. 2001, Getz et al. 2001).

Superimposed over these regular cycles and random fluctuations are stochastic factors such as weather or wide-spread catastrophic occurrences that will mediate population size (Garsd and Howard 1981, Bowman et al. 2001, Getz et al. 2001, Stokes et al. 2001). For example, the winter of 1995-1996 was particularly long and harsh with significant snowfall accumulation for the region. Within the context of fairly wide oscillations in population size, small mammal responses to aspen clearcutting may vary depending on population processes related to these oscillations. For instance, high population levels within intact forests surrounding clearcuts may pressure individuals to be displaced into the clearcut, presumably due to intraspecific social pressures and/or interspecific competition and exclusion (Kirkland 1990). Under conditions of varying reproductive output, rates of immigration and emigration, juvenile recruitment and community complexity, behaviour and habitat selection of individual species may vary in response to changes in their environment. Results of this dynamic process are difficult to predict given that researchers typically do not consider large-scale population performance when examining relatively small-scale disturbances (e.g., Drost and Fellers 1991). Additionally, the magnitude of natural population fluctuations may be greater than the magnitude of the effects of the disturbance and will depend on the initial population density, the community composition, and the species in question. Most small mammal populations respond to disturbance events (man-made and natural) by dramatically increasing following a crash; stable populations may take years to achieve. A series of a variety of disturbances (e.g., harvesting and an extreme winter) would each impact the population, and it would be difficult to determine the true effect of one disturbance or another.

Although species abundance is typically measured to determine effects of forest management practices on small mammal communities, it may be an inappropriate indicator of habitat quality (Van Horne 1983). With this in mind, results of our study should be viewed with caution, and interpretations of differences should not always infer assessment of habitat values. Measurement of demographic characteristics (fecundity, survivorship, recruitment, rates of emigration and immigration) of individual species within the various habitat types (stand ages) is perhaps the only method of determining relative habitat qualities. To obtain these types of data, more intensive sampling than was used in this study would have to be employed.

7 MANAGEMENT IMPLICATIONS

The following recommendations have been made in a variety of research and management contexts to mitigate and minimize effects of aspen (or other) harvesting on wildlife and wildlife diversity.

1. Follow a landscape-level harvest schedule that ensures stands of all age classes and conditions are available as wildlife habitat at all times.
2. Follow a landscape-level development plan that spatially and temporally mirrors natural disturbance patterns such as fire (reflected in block size limitations and variation across the landscape, minimal habitat fragmentation and reserves of mature timber that will not be harvested over the span of the rotation) .
3. Plan leave-strips between adjacent cutblocks and buffer strips along riparian corridors and other important habitats.
4. Retain single trees and/or patches of unharvested timber within the cutblock (reflecting the diversity of tree species in the original stand, with the objective of maintaining and/or recruiting wildlife trees) and corridors of unharvested timber between retention patches within the cutblock and the contiguous forest and/or reserves and/or high-value riparian habitat.
5. Maintain and/or develop structural complexity in the regenerating stand .
6. Maintain and/or develop a diversity of volumes and sizes of woody debris in the regenerating stand.
7. Ensure fewer physical disturbances that require intensive rehabilitation (e.g., roads and landings).

These recommendations are discussed below in the context of aspen harvesting in northeastern British Columbia. Results of our songbird and owl surveys on mixed-wood forests are not at a level from which we can make substantive recommendations for that forest type.

7.1 Aspen Management: Natural Disturbance Regimes

In boreal forests of North America, forest fires are recognized as a major disturbance agent that tends to be frequent (every 50-100 years), catastrophic

(killing most of existing stands) and variable in size (20-17,000 ha) (Hunter 1993, Telfer 1993, Eberhart and Woodard 1984). Fires can skip as much as 15-20% of an area (Eberhart and Woodard 1984), leaving considerable amounts of standing live and dead trees and woody debris (DesGranges and Rondeau 1993). Within a region, some areas may be burned repeatedly, whereas others remain unburned for many years (Telfer 1993). Fire in the boreal forest results in the development of a wide variety of habitats of varying stand age in a patchy arrangement (Telfer 1993).

Many wildlife species in the boreal forest have evolved to use a wide diversity of the habitats within the fire-generated landscape (Telfer 1993), but others are limited to particular stand ages and habitat types. Maintenance of wildlife diversity in the boreal forest, therefore, is dependent on the provision of a variety of habitat types and stand ages over various geographic scales (Crouch 1983, Thompson and Capen 1988, Desgranges and Rondeau 1993, Welsh 1993, Easton and Martin 1998).

Efforts to mimic a natural fire regime to benefit wildlife have led to various conclusions. Scott and Crouch (1987) concluded that cutting 25% of the overstorey in mature aspen forest in Colorado should adversely affect few forest-dwelling birds. DeByle (1981) and Scott and Crouch (1988b) concluded that clearcutting aspen in small blocks on an 80-year rotation should provide a mosaic of age and size classes, increase "edge," and increase bird species diversity and possibly even the total number of birds. Some authors recommend that both size and habitat heterogeneity of forest fragments be maximized to maintain a diverse bird fauna in temperate forests (Freemark and Merriam 1986, Hagan et al. 1996). Other authors suggest that fewer but larger clearcuts will decrease the negative effect of edge on some forest-nesting birds such as Ovenbird (King et al. 1996) and Least Flycatcher (DellaSala and Rabe 1987).

However, applying natural disturbance patterns on the ground is complicated. Martin (1992) warned that the attention given to landscape and fragmentation issues on a local level has led to an overgeneralization of patterns, without a clear understanding of the processes involved, and that this trend may be focusing attention on inappropriate management actions.

7.2 Aspen Management: Retention Patches and Woody Debris

Retention of portions of existing forests within clearcuts has received considerable attention as a management tool (Freedman et al. 1981, Hansen et al. 1995, Norton and Hannon 1997, Merrill et al. 1998). The extent to which clearcutting affects forest-associated wildlife species may be moderated by the degree to which forest attributes are maintained in harvested areas (Norton and Hannon 1997). Partial cutting retains old-forest attributes and provides some habitat for birds (Freedman et al. 1981, Triquet et al. 1990, Hansen et al. 1995, Norton and Hannon 1997, Merrill et al. 1998) and mammals (Von Trebra et al. 1998, Sullivan et al. 2000) normally associated with later seral stages.

Several attributes and condition of retention patches appear to be important – particularly patch size, distribution of retention patches on a block, similarity to the original forest, connectivity and riparian character. Patch size has been positively correlated with species richness of birds in aspen forests (Hannon 1993, Schieck and Hobson 2000) and with bird species diversity and abundance and aspen grove size in aspen parkland (Johns 1993). Several authors have reported that the assemblage of bird species utilizing larger patches more closely resembles intact mature hardwood and softwood stands than smaller patches (Ambuel and Temple 1983, Blake and Karr 1984, Lynch and Whigham 1984, Johns 1993, Schieck and Hobson 2000). Patch size is also correlated with diversity of mammal species in hardwood forests, but mammals tend to be more habitat generalists and many can adapt to some level of canopy removal in their area.

Little is known regarding the best distribution of retention patches in aspen cutblocks because aspen trees have seldom been left on a block because of conflicts with silviculture and aspen regeneration. However, bird communities in cutblocks in the mixedwood boreal forest in Alberta were more similar to those in old forests if residual trees were retained in small patches throughout the cutblock rather than as scattered trees (Schieck et al. 2000).

Retention patches should be representative of the original forest to provide critical habitat parameters (structural elements) such as suitable trees for nesting,

foraging and thermal protection. For example, Yellow-bellied Sapsuckers excavate cavities in large-diameter aspen and drill sap wells in mature birch trees (Ehrlich et al. 1988), while mustelids den and forage at the base of large trees and under woody debris (Harris 1984a). To provide essential nesting, denning or foraging habitat for a variety of species in a managed aspen forest, retention patches must include trees of an age, size, decay class and species composition that is typical of the original forest.

Furthermore, retention patches that are connected to intact surrounding forests have a bird assemblage more closely resembling mature stands than unconnected patches (Booth and Merkens 1997, Schmiegelow et al. 1997). Some mice, voles and their predators are more likely to be found in clearcuts with regularly spaced retention patches, partial canopy cover and connecting corridors than in cleared areas (Butts 1997, Sullivan et al. 2000). Use of corridors by all wildlife is at least equal to use of the surrounding areas: edges are used extensively for feeding and hunting, and the middle of the corridor is used primarily for shelter and travel. Corridors that link retention patches have been shown to provide dispersal routes for juvenile songbirds as well as nesting habitat for some species (Machtans et al. 1996, Schmiegelow et al. 1997). Corridors are also used at the landscape level by mammals for dispersal and movement to favoured habitats (Harrison and Voller 1998) and at the stand level when linking retention patches with the standing forest.

Although riparian areas in our study area were limited to ephemeral streams and drainages, current practices often select these wet areas as leave areas. Aspen trees growing in these wet areas are generally larger in diameter and have other characteristics of wildlife trees (Manning et al. 2001), and they should be considered in retention planning. Riparian corridors are expected to play an essential role in landscape planning by, among other things, benefiting wildlife (Naiman et al. 1993). LaRue et al. (1995) found that bird species abundance and richness was significantly higher in riparian than upland stands in boreal forests of eastern Quebec. High avian species richness in hardwood riparian areas relative to adjacent upland sites has been reported by many other authors (Stauffer and Best 1980, Emmerich and Vohs 1982). Wider riparian corridors (e.g., 60-m strips) could support avifauna similar to that of large forest tracts (Darveau et al. 1995), and this is likely true for mammals as well. Cutblock retention patches that incorporate riparian habitats, with their naturally heterogeneous vegetation communities and high species abundance and diversity (Bunnell and Dupuis 1993), will likely enhance breeding bird communities on clearcuts in aspen forests of northeastern British Columbia (Schmiegelow et al. 1997).

The use of retention patches as a management tool is not without its drawbacks, particularly for birds. Studies in the United States have documented increased bird predation and brood parasitism in fragmented forests or at forest edges (Brittingham and Temple 1983, Wilcove 1985, Andren and Angelstam 1988, Ehrlich et al. 1988, Small and Hunter 1988, Yahner and Scott 1988, Robinson et al. 1995). King et al. (1996) found that the survival of Ovenbird nests in New Hampshire was significantly lower at the forest edge than in the forest interior, but that overall reproductive success was not significantly different. The authors did not know whether the increase in reproductive effort associated with replacement clutches decreased the survival of adults. Brittingham and Temple (1983) concluded that as cowbird populations steadily increased and forest habitat remained fragmented in eastern forests, brood parasitism likely was a major factor in both maintaining and accelerating the declines in forest-interior songbirds. Robinson et al. (1995) found that nest predation and parasitism by cowbirds increased with forest fragmentation in nine midwestern landscapes that varied between six and 95% forest cover. Contrary to these findings, Hannon (1993), Rudnicky and Hunter (1993) and Schmiegelow et al. (1997) suggest that some of these impacts may not be as important in boreal forests because increased bird nest predation and brood parasitism in small fragments have not been noted to the same extent in boreal forests. In addition, birds known to be sensitive to area effects in studies in the eastern U.S. have been detected in relatively small forest patches in the boreal forest (Welsh 1987 cited in Hannon 1983, Hannon 1993); however, these results are preliminary and are by no means conclusive.

The effects of harvesting on bird depredation and brood parasitism were not investigated during the current study. Species such as Ovenbird, Black-and-white Warbler and Connecticut Warbler, which nest on or near the ground, may be more prone to increased nest depredation by mammalian predators (Ehrlich et al. 1988). At Del Rio, the parasitic Brown-headed Cowbird was recorded at a similar abundance in mature forests and old clearcuts (Table 16) but at a significantly lower

abundance in young clearcuts. It is possible that harvesting resulted in greater impacts of brood parasitism and/or predation on some species (e.g., Ovenbird), but our data is unable to confirm gradual increases in cowbird numbers and/or subsequent long-term declines in songbird abundance.

Another drawback of the use of retention blocks is illustrated in studies by Darveau et al. (1995), who found that birds "crowded" into riparian leave-strips in the year immediately following cutting (i.e., 30-70% increase). Crowding into retention patches could similarly lead to increased competition for food and nest sites and reduced survival of eggs, nestlings and adults. However, Darveau et al. (1995) reported that densities declined to pre-treatment levels in subsequent years, so crowding was really a short-term phenomenon. Similar responses by small mammals might be observed, but because they are less mobile than birds, crowding may have a longer-term effect.

Drawbacks of retention, corridors or riparian leave-strips for mammals are not well documented. Chan MacLeod (pers. comm. 1995) found that the number of Deer Mouse and Red-backed Vole at the clearcut edge was lower than in the cleared area and the standing forest. She hypothesized that there may be more predation, fewer resources and an unfavorable microclimate at the edge. Other hypothetical disadvantages of corridors include reduced genetic variation, increased exposure to predators and spread of contagious catastrophes such as fire, diseases and pests (Harrison and Voller 1998).

Despite its drawbacks, retention is still considered favourably as a management tool to conserve biological diversity in the harvested landscape. A compromise approach should be taken that mimics large-scale disturbance in the boreal forest, considers economic and ecological factors, and accommodates forest fragmentation concerns and the concerns of the public about large-scale clearcutting (Hunter 1993, Delong and Tanner 1996). Norton and Hannon (1997) suggest that until the role of retention patches in maintaining avian species productivity and diversity can be better understood, a target of 40% retention should be sought. Retention patch size, linkages, clearcut size, and overall forest fragmentation at the landscape level are important considerations for forest managers.

Managers must not, however, depend on retention patches, reserve areas or corridors to fully conserve biological diversity across a landscape. High local species diversity may be a result of managing for local habitat diversity; however, avian species diversity on a landscape level may be compromised if species adversely affected by the reduction in habitat size are extirpated (Welsh and Healy 1993). For example, studies on breeding birds in northern Finland indicated that despite the protection of old-growth natural reserves, the bird fauna of these reserves was markedly influenced by changes in the larger surrounding areas (Vaisanen et al. 1986). The decrease of birds of old taiga forests and the simultaneous increase of generalist species indicated a general reduction in diversity in biota of Finland's northern forests. Similarly, in boreal mixed-wood forests in northwestern Quebec, the higher proportion of early successional habitats in human-disturbed landscapes resulted in significantly higher abundance of early-successional and generalist bird species (Drapeau et al. 2000). And, in a mixed forest in Connecticut, Askins and Philbrick (1987) found that populations of many bird species were not self-sufficient in a small preserve, but instead were part of a larger, regional population. Conclusions from these studies of local and landscape effects likely also apply to small mammals in aspen forests of northeastern British Columbia.

In addition to retaining forest canopy and overstorey characteristics in retention patches, forest managers are recommended to maintain ground-level attributes of mature forests in the patches and throughout the cutblock. Amount, size and distribution of woody debris may determine presence in and use of a cutblock by many birds and mammals. Generally, mammals use the debris for safe travel corridors and foraging (Planz and Kirkland 1992, Lofroth 1998, Merkens and Booth 1998b), while birds use it for perching and foraging (Thomas 1979, Ehrlich et al. 1988). Numbers of Deer Mouse and Red-backed Vole are correlated with the frequency of woody material on the ground, and Deer Mouse numbers are not correlated to percent overstorey (Scott and Crouch 1988c). Planz and Kirkland (1992) reported a significant decrease in numbers of small mammal captures in an area cleared of woody debris. In contrast, Butts (1997) found that some small mammal capture rates generally did not increase with debris volume, though some species were positively associated with percent debris cover and other habitat attributes. Similarily, Moses (1995) found no measurable effects of slash or tree retention on Deer Mouse and Red-backed Vole

numbers in a harvested forest. However, structural complexity, including elements of forest floor debris, is thought by some to be the key to high abundance and richness of vertebrate communities and especially small mammal communities (Thomas 1979, Caza 1993, Roy et al. 1995, Lofroth 1998).

7.3 Management Recommendations

A prudent approach to the management of aspen forests in the Dawson Creek Forest District should incorporate patterns of natural disturbance by:

1. maintaining large, unfragmented mature aspen stands distributed across the landscape and over time.
2. retaining forest patches within aspen harvest blocks to maintain forest structure across the landscape. Retention patches should be representative of the adjacent intact forest and include large-diameter aspen with visible signs of heart rot. Patch size should be maximized (i.e., > 5 ha) and connected to intact forest. Size and distribution of patches should be varied across the landscape and over time.
3. retaining slash piles, which are important to some species such as Dark-eyed Junco, Lincoln's Sparrow, Deer Mouse and Marten. Some large pieces (large diameter and long length) and some small pieces of woody debris should be left scattered throughout the harvested block. Slash piles should not be routinely burned because they serve as valuable resting and foraging habitat.
4. extending harvest rotations beyond 40 years (to 60-80 years or more) to allow aspen stems to mature and consequently develop heart rot. Mature veteran stands are required in a clumped distribution across a given landscape to mimic natural disturbances.

In addition, managers must recognize that significant annual fluctuations in species abundance, such as those observed in this and other studies in boreal and other forests, are normal and may result in misleading interpretation of short-term studies. Also, the presence of an apparently breeding mammal or songbird does not imply successful breeding.

8 FUTURE RESEARCH

1. Studies should continue over the long term to assess changes in bird diversity and abundance as stand characteristics change and to determine the impacts of annual variations on interpretations of short-term data. This study currently includes a three-year return interval for surveying forest songbirds in the 15 study blocks at Del Rio (the next surveys are to be conducted in summer 2002). An intensive statistical analysis of the 1992-2002 songbird data should be conducted by a statistician familiar with avian populations and management issues. An assessment is required of correlations and associations between changes in wildlife diversity (species richness and abundance, patterns of community dominance) and changes in the habitat variables we measured.
2. Mid-aged stands (i.e., 20- to 60-year-old) should be sampled to determine at what stand age forest-associated species, particularly listed species, re-colonize regenerating stands.
3. Studies should be initiated to compare reproductive success of birds and small mammals in intact forests, retention patches, and mid-aged stands to determine how commercial harvesting is affecting populations. Determining whether retention patches are providing adequate breeding habitat is a priority. Studies are required to determine optimum size and characteristics of retention patches and their role in small mammal and songbird dynamics and reproductive success. Spot mapping of bird territories can be used to determine whether singing males are breeding, but more intensive studies would be required to assess reproductive success. More intensive small mammal sampling (1-ha trapping grids of 49 trap stations, sampled eight times from May through October) should be considered to determine demographic parameters that reflect habitat quality.
4. Birds should be surveyed during wintering or migratory seasons to determine use of mature aspen forests, clearcuts and retention patches during non-breeding seasons. More intensive inventories of owls in landscapes of unharvested and harvested aspen and mixed-wood forests are required, along with habitat assessments to determine critical habitat parameters and the effects of forestry on northern forest owls.
5. Surveys should be conducted on woodpeckers in mature aspen forests, retention patches and harvested areas, because woodpeckers are indicators of old forest attributes within all forested stands. The reader is directed to Merkens and Booth (1997), Manning and Chytyk (1997) and Manning et al. (2001) for results of surveys conducted in aspen and

mixed-wood forests in the Del Rio and Murray River areas during the course of this study.

6. The relationship should be investigated between clearcut size and frequency in a landscape and the overall impact on regional bird populations.

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TABLES

Table 1. Sequence of establishing and surveying study blocks in the Del Rio and Tate Creek study areas. Mature, unharvested study blocks are denoted by M; otherwise, the age of harvested blocks is indicated. Shaded cells represent study blocks not surveyed or yet established. Surveys at Tate Creek were discontinued after the 1995 season because of reduced funding and access difficulties. Superscript notation indicates (a) blocks used in Merkens and Booth's (1998) analysis of year effects for birds and small mammals in mature stands, and (b) blocks used in Merkens and Booth's examination of the potential changes in bird and small mammal richness and species abundance as a result of forest harvesting.

Study Block	1992	1993	1994	1995	1996	1997	1999
Del Rio							
B1	M	M[a]	Ma	M[a,b]	M[a,b]	M[a,b]	1 yr old
B2	M	M[a]	Ma	M[a,b]	M[a,b]	M[a,b]	1 yr old
B3	M	M[a]	Ma	M[a,b]	M[a,b]	M[a,b]	1 yr old
C1	M	M[a]	M[a]	M[a,b]	M[a,b]	M[a,b]	M
C2	M	M[a]	M[a]	M[a,b]	M[a,b]	M[a,b]	M
CC	M	M[a]	M[a]	M[a,b]	M[a,b]	M[a,b]	M
NC		M[a]	M[a]	M[a,b]	M[a,b]	M[a,b]	M
PG	M	M	M	1 yr old[b]	2 yr old[b]	3 yr old[b]	5 yr old
C92	M	M	M	1 yr old[b]	2 yr old[b]	3 yr old[b]	5 yr old
DM	M	M	M	1 yr old[b]	2 yr old[b]	3 yr old[b]	5 yr old
TC			3 yr old	4 yr old[b]	5 yr old[b]	6 yr old[b]	8 yr old
PS			3 yr old	4 yr old[b]	5 yr old[b]	6 yr old[b]	8 yr old
NC97						1 yr old	3 yr old
MC97						1 yr old	3 yr old
WC97						1 yr old	
Tate Creek							
KC1	M	M	M	M			
KC2		M	M	M			
K82	M	1 yr old	2 yr old	3 yr old			
K83	M	1 yr old	2 yr old	3 yr old			

Table 2. Bird species detected more than10 times in any year in the Del Rio study area and hence included in abundance analyses. Stand age comparisons among mature forest and old and young clearcuts included 29 species; however, four species (marked with an asterisk) were not included in between-year analyses of mature stands because of insufficient numbers. Species codes, scientific names and common names are in Appendix A.

ALFL *	COYE *	NOWA	REVI	WETA
AMRE	DEJU	OCWA	RWBL	WTSP
AMRO	GRJA	OVEN	SOSA	YBSA
BHCO	LEFL	PHWA	SWTH	YEWA
BTNW	LEYE *	RBGR	TEWA	YRWA
CCSP *	LISP	RBNU	WAVI	

Table 3. Number of 20 x 20 m vegetation plots (V) and security cover sampling plots (S) in the Del Rio and Tate Creek study areas.

	Number of plots assessed											
	1993		1994		1995		1996		1997		1999	
	V	S	V	S	V	S	V	S	V	S	V	S
Del Rio												
B1	2	7									2	2
B2	2	7									2	2
B3	2	7									2	2
C1	2	7										
C2	2	7										
NC	2	22										
CC	2	22										
PG	2	7			2	5			2	2		
C92	2	7			2	7			2	2		
DM	2	7			2	7			2	2		
TC			2	7	2	7			2	2	2	2
PS			2	7	2	7			2	2	2	2
NC97									2	2		
MC97									2	2		
WC97									2	2		
Tate Creek												
KC1	2											
KC2	2											
K82	2				2							
K83	2				2							

Table 4. Number of study blocks surveyed for vegetation and security cover in the Del Rio area by year and stand age.

Stand Age	1993	1994	1995	1997	1999
Mature	10				
1-year-old cut			3	3	3
3-year-old cut		2		3	
4-year-old cut			4		
6-year-old cut				2	
8-year-old cut					2

Table 5. Small mammal trapping surveys, Del Rio and Tate Creek, 1992-1997. In 1994, the fall survey was conducted on one half of the traps stations (indicated by four surveys) or not at all (indicated by three surveys). In 1996, due to delays in funding, only two spring surveys were conducted. Shaded cells represent study blocks not surveyed or yet established. Surveys at Tate Creek were discontinued after the 1995 season because of reduced funding and access difficulties. See Table 1 for stand ages. Superscript notation indicates (a) blocks used in Merkens and Booth's (1998) analysis of year effects for small mammals in mature stands and (b) blocks used in Merkens and Booth's examination of the potential changes in small mammal richness and species abundance as a result of forest harvesting.

Study Block	1992	1993	1994	1995	1996	1997	1999
Del Rio							
B1	2	4^{a}	4^{a}	$4^{a,b}$	$3^{a,b}$	$4^{a,b}$	
B2	2	4^{a}	4^{a}	$4^{a,b}$	$3^{a,b}$	$4^{a,b}$	
B3	3	4^{a}	4^{a}	$4^{a,b}$	$3^{a,b}$	$4^{a,b}$	
C1	2	4^{a}	4^{a}	$4^{a,b}$	$3^{a,b}$	$4^{a,b}$	
C2	3	4^{a}	4^{a}	$4^{a,b}$	$3^{a,b}$	$4^{a,b}$	
CC	2	4^{a}	4^{a}	$4^{a,b}$	$3^{a,b}$	$4^{a,b}$	
NC		4^{a}	4^{a}	$4^{a,b}$	$3^{a,b}$	$4^{a,b}$	
PG	3	4	3	4^{b}	3^{b}	4^{b}	
C92	2	4	3	4^{b}	3^{b}	4^{b}	
DM	2	4	3	4^{b}	3^{b}	4^{b}	
TC			4	4^{b}	3^{b}	4^{b}	
PS			4	4^{b}	3^{b}	4^{b}	
NC97						4	
MC97						4	
WC97						4	
Tate Creek							
KC1	3	4	3	4			
KC2		4	3	4			
K82	3	4	3	4			
K83	3	4	3	4			

Table 6. Total count and mean number of individuals observed per block per year of the 10 most abundant bird species recorded in mature and harvested blocks combined at Del Rio, 1992-1997 and 1999, and Tate Creek, 1992-1995.

Rank	Del Rio	Total	Mean	Tate Creek	Total	Mean
1	White-throated Sparrow	836	10.0	White-throated Sparrow	162	10.8
2	Least Flycatcher	790	9.4	Lincoln's Sparrow	78	5.2
3	Swainson's Thrush	524	6.2	Yellow-rumped Warbler	68	4.5
4	Yellow Warbler	507	6.0	Least Flycatcher	64	4.3
5	Lincoln's Sparrow	475	5.7	Yellow Warbler	62	4.1
6	Ovenbird	352	4.2	Warbling Vireo	44	2.9
7	Yellow-rumped Warbler	304	3.6	Dark-eyed Junco	44	2.9
8	Brown-headed Cowbird	302	3.6	Brewer's Blackbird	42	2.8
9	Clay-colored Sparrow	266	3.2	Brown-headed Cowbird	39	2.6
10	Yellow-bellied Sapsucker	225	2.7	American Robin	38	2.5
Total		4,581	54.6		641	42.6

Table 7. Total count and mean number of individuals of red (R) and blue-listed (B) bird species per block per year recorded in mature aspen and harvested blocks at Del Rio, 1992-1999, and Tate Creek, 1992-1995.

	Del Rio		Tate Creek	
	Total	Mean	Total	Mean
[B] Philadelphia Vireo	80	1.0	12	0.8
[B] Black-throated Green Warbler	46	0.5	6	0.4
[R] Connecticut Warbler	17	0.2	4	0.3
[B] Le Conte's Sparrow	6	0.1		
[B] Sandhill Crane	Incid.	Incid.		

Table 8. Results of follow-up paired t-tests for between-year comparisons of bird species richness using species encountered on surveys of mature aspen and harvested blocks at Del Rio, 1995-1997.

Year Comparison	Cumulative mean no. of species/ block	Result of t-test	t-value, 11df	p
1995-1996	21 vs 17	1995>1996	3.26	0.008
1995-1997	21 vs 20	no difference	0.42	0.68
1996-1997	17 vs 20	1996<1997	-2.43	0.033

Table 9. Results of follow-up paired t-tests for between-year comparisons of bird species richness using all species including incidental species in mature aspen and harvested blocks at Del Rio, 1995-1997.

Year Comparison	Cumulative mean no. of species/ block	Result of t-test	t-value, 11df	p
1995-1996	28 vs 21	1995>1996	6.01	<0.001
1995-1997	28 vs 25	1995>1997	2.54	0.028
1996-1997	21 vs 25	1996<1997	-2.43	0.033

Table 10. Number of bird species reported during surveys and as incidentals in mature blocks at Del Rio, 1992-1999, and Tate Creek, 1992-1995.

	Del Rio				Tate Creek			
Year	No. mature blocks	Survey	Incidental	Total	No. mature blocks	Survey	Incidental	Total
1992	9	35	12	47	3	25	10	35
1993	10	41	14	55	2	32	2	34
1994	10	38	20	58	2	24	5	29
1995	7	39	12	51	2	32	4	36
1996	7	34	10	44				
1997	7	36	10	46				
1999	4	33	6	39				

Table 11. Total and mean number of individual birds reported during surveys in mature blocks at Del Rio, 1992-1999, and Tate Creek, 1992-1995.

	Del Rio			Tate Creek		
Year	No. mature blocks	Total	Mean	No. mature blocks	Total	Mean
1992	9	651	72.3	3	177	59.0
1993	10	1,114	111.4	2	207	103.5
1994	10	595	59.5	2	114	57.0
1995	7	731	104.4	2	188	94.0
1996	7	511	73.0			
1997	7	724	103.4			
1999	4	391	97.8			

Table 12. Change in abundance[1] of 15 common bird species in seven mature forests at Del Rio, 1993-1999. Values for 1999 (based on four mature forest blocks) are included as reference but are not part of the statistical analyses.

Species	Mean number of detections per point count per block						$F_{(4,24)}$	p
	1993	1994	1995	1996	1997	1999		
American Redstart	0.13	0.12	0.51	0.77	0.54	0.19	13.89	<0.001
American Robin	0.33	0.08	0.19	0.20	0.10	0.21	3.13	0.033
Brown-headed Cowbird	0.46	0.07	0.30	0.20	0.40	0.38	8.47	<0.001
Dark-eyed Junco	0.10	0.15	0.08	0.02	0.01	0.04	2.94	0.041
Least Flycatcher	1.02	0.60	1.06	1.30	1.48	1.48	6.89	0.001
Lincoln's Sparrow	0.05	0.07	0.45	0.05	0.05	0.02	7.69	<0.001
Ovenbird	0.54	0.24	0.54	0.73	0.67	0.58	6.71	0.001
Philadelphia Vireo	0.10	0.06	0.19	0.30	0.19	0.02	3.66	0.018
Rose-breasted Grosbeak	0.07	0.07	0.24	0.18	0.21	0.19	2.79	0.049
Red-breasted Nuthatch	0.20	0.18	0.02	0.04	0.02	0.10	7.44	<0.001
Red-eyed Vireo	0.19	0.13	0.24	0.54	0.46	0.35	8.83	<0.001
Swainson's Thrush	0.60	0.19	0.94	1.07	1.04	0.77	15.57	<0.001
Tennessee Warbler	0.03	0.05	0.00	0.16	0.24	0.00	8.57	<0.001
White-throated Sparrow	0.73	0.53	1.26	1.16	0.82	0.83	10.28	<0.001
Yellow Warbler	0.65	0.25	0.45	0.68	0.76	0.88	8.11	<0.001

[1] Mean number of detections per point count per block

Table 13. Mean number of individual birds per block (number of blocks in brackets) observed on surveys in mature aspen and harvested study blocks at Del Rio, 1992-1999, and Tate Creek, 1992-1995. Lines connect data for individual harvested blocks as the blocks age after harvesting. Means of the means are also presented.

Year	Del Rio					Tate Creek			Mean
	Mature	1-2 year	3-4 year	5-6 year	7-8 year	Mature	1-2 year	3-4 year	
1992	72.3 (9)	-	-	-	-	59.0 (3)	-	-	65.7
1993	111.4 (10)	-	-	-	-	103.5 (2)	86.5 (2)	-	101.5
1994	59.5 (10)	-	63.0 (2)	-	-	57.0 (2)	44.5 (2)	-	56.0
1995	104.4 (7)	52.0 (3)	153.0 (2)	-	-	94.0 (2)	-	93.0 (2)	99.3
1996	73.0 (7)	41.3 (3)	-	77.0 (2)	-	-	-	-	63.8
1997	103.4 (7)	70.7 (3)	96.7 (3)	114.5 (2)	-	-	-	-	96.3
1999	97.8 (4)	60.3 (3)	100.0 (2)	109.7 (3)	114.5 (2)	-	-		96.5
Mean	88.8	56.1	103.2	100.4	114.5	78.4	65.5	93.0	82.7

Table 14. Bird abundance[1] in aspen study blocks surveyed before and after harvesting at Del Rio, 1992-1999, and Tate Creek, 1992-1995. Blocks NC and KC2 were not surveyed in 1992. Stand age: M = mature; 1 = one-year-old cutblock (first year after harvest); 2 = two-year-old cutblock; etc.

Year	Del Rio						Tate Creek			
	C92, PG, DM		B1, B2, B3		C1, C2, CC, NC		K82, K83		KC1, KC2	
	Age	Abund.	Age	Abund.	Age	Abund.	Age	Abund.	Age	Abund.
1992	M	76.7	M	63.3	M	77.0	M	72.5	M	32.0
1993	M	126.7	M	110.3	M	100.8	1	86.5	M	103.5
1994	M	63.7	M	59.7	M	56.3	2	44.5	M	57.0
1995	1	52	M	102.0	M	106.3	3	93.0	M	94.0
1996	2	41.3	M	79.7	M	68.0				
1997	3	96.7	M	113.7	M	95.8				
1999	5	109.7	1	60.3	M	97.8				

[1] Mean number of individuals/block

Table 15. Mean abundance[1] and standard errors of forest birds in mature aspen forest, young clearcuts and old clearcuts, Del Rio, 1995-1997. Three young clearcuts (C92, DM and PG) were one-year-old clearcuts in 1995; two old clearcuts (TC and PS) were three-year-old clearcuts in 1995. The seven mature blocks were B1, B2, B3, C1, C2, CC, and NC.

Bird species	Mature		Young clearcuts		Old clearcuts	
	Mean	SE	Mean	SE	Mean	SE
Alder Flycatcher	0.00	0.00	0.79	0.18	2.33	0.33
American Redstart	1.82	0.25	0.39	0.39	0.35	0.02
American Robin	0.48	0.06	0.26	0.05	0.67	0.21
Brown-headed Cowbird	0.90	0.16	0.28	0.15	2.17	0.29
Black-throated Green Warbler	0.29	0.18	0.00	0.00	0.00	0.00
Clay-colored Sparrow	0.00	0.00	1.94	0.53	3.75	0.67
Common Yellowthroat	0.00	0.00	1.10	0.16	2.92	0.00
Dark-eyed Junco	0.11	0.04	1.38	0.44	0.35	0.35
Gray Jay	0.20	0.09	0.18	0.18	0.10	0.02
Least Flycatcher	3.84	0.89	0.21	0.17	1.56	0.31
Lesser Yellowlegs	0.00	0.00	0.44	0.18	0.38	0.29
Lincoln's Sparrow	0.55	0.16	3.53	0.26	4.13	0.29
Northern Waterthrush	0.10	0.05	0.03	0.03	0.13	0.04
Orange-crowned Warbler	0.04	0.02	0.19	0.07	1.13	0.25
Ovenbird	1.93	0.38	0.00	0.00	0.00	0.00
Philadelphia Vireo	0.68	0.10	0.03	0.03	0.00	0.00
Rose-breasted Grosbeak	0.63	0.11	0.13	0.09	0.27	0.10
Red-breasted Nuthatch	0.08	0.03	0.00	0.00	0.00	0.00
Red-eyed Vireo	1.24	0.19	0.06	0.06	0.44	0.27
Red-winged Blackbird	0.00	0.00	0.08	0.08	0.56	0.19
Solitary Sandpiper	0.05	0.04	0.14	0.04	0.08	0.00
Swainson's Thrush	3.05	0.17	0.40	0.36	0.77	0.15
Tennessee Warbler	0.40	0.09	0.15	0.15	0.17	0.17

...continued

Table 15. (continued)

Bird species	Mature		Young clearcuts		Old clearcuts	
	Mean	SE	Mean	SE	Mean	SE
Warbling Vireo	0.85	0.26	0.17	0.17	0.21	0.04
Western Tanager	0.51	0.12	0.00	0.00	0.04	0.04
White-throated Sparrow	3.24	0.39	2.10	0.26	2.23	0.31
Yellow-bellied Sapsucker	0.75	0.04	0.21	0.13	0.25	0.08
Yellow Warbler	1.89	0.38	0.39	0.24	2.60	0.10
Yellow-rumped Warbler	1.54	0.19	0.03	0.03	0.00	0.00

[1] Number of detections per point count per block

Table 16. Results of repeated-measures ANOVA and follow-up one-way ANOVA with Duncan's multiple range tests for bird species for which a significant difference in abundance among stand age was recorded, Del Rio, 1995-1997. Three younger clearcuts (YC) were one, two, and three years old, and two older clearcuts (OC) were four, five, and six years old, in 1995-1997. Seven mature forests (M) were unharvested.

Species	Repeated-measures ANOVA		Duncan's multiple range tests		
	$F_{(2,9)}$	p	1-way ANOVA	$F_{(2,11)}$	p
American Redstart	7.76	0.011	M>(YC,OC)[a]	7.76	0.011
Ovenbird	8.20	0.009	M>(YC,OC)	8.20	0.009
Philadelphia Vireo	12.76	0.002	M>(YC,OC)	12.76	0.002
Red-eyed Vireo	8.75	0.008	M>(YC,OC)	5.11	0.033
Swainson's Thrush	39.26	<0.001	M>(YC,OC)	39.26	<0.001
Yellow-bellied Sapsucker	19.34	0.001	M>(YC,OC)	19.34	0.001
Yellow-rumped Warbler	19.44	0.001	M>(YC,OC)	19.44	0.001
Western Tanager	5.29	0.03	M>YC	5.29	0.03
Rose-breasted Grosbeak	5.11	0.033	M>YC	8.75	0.008
Yellow Warbler	4.99	0.035	(OC,M)>YC	4.99	0.035
Brown-headed Cowbird	13.86	0.002	(OC,M)>YC	13.86	0.002
Dark-eyed Junco	10.22	0.005	YC>(M,OC)	10.22	0.005

[a] Relationship among stand ages is indicated. For example, American Redstart was more abundant in mature stands than in either young or older clearcut areas, whereas Dark-eyed Junco was more abundant in young clearcuts than in mature stands or older clearcuts.

Table 17. Mean number of bird species per block (number of blocks in brackets) observed on surveys in mature aspen and harvested study blocks, Del Rio, 1992-1999, and Tate Creek, 1992-1995. Lines connect data for individual harvested blocks as the blocks age after harvesting. Means of the means are also presented.

Year	Del Rio					Tate Creek			Mean
	Mature	1-2 year	3-4 year	5-6 year	7-8 year	Mature	1-2 year	3-4 year	
1992	15.3 (9)	-	-	-	-	15.7 (3)			15.5
1993	20.5 (10)	-	-	-	-	24.0 (2)	17.5 (2)		20.7
1994	17.5 (10)	-	18.5 (2)	-	-	17.5 (2)	12.0 (2)		16.4
1995	21.1 (7)	15.7 (3)	26.0 (2)	-	-	24.0 (2)		19.0 (2)	21.2
1996	18.0 (7)	13.7 (3)	-	17.5 (2)	-				16.4
1997	19.3 (7)	20.3 (3)	18.3 (3)	26.5 (2)	-				21.1
1999	20.8 (4)	17.7 (3)	21.5 (2)	22.3 (3)	22.0 (2)				20.9
Mean	18.9	16.9	21.1	22.1	22.0	20.1	14.8	19.0	18.9

Table 18. Bird species richness[1] in aspen study blocks surveyed before and after harvesting at Del Rio, 1992-1999, and Tate Creek, 1992-1995. Blocks NC and KC2 were not surveyed in 1992. Stand age: M = mature; 1 = one-year-old cutblock (first year after harvest); 2 = two-year-old cutblock; etc.

Year	Del Rio						Tate Creek			
	C92, PG, DM		B1, B2, B3		C1, C2, CC, NC		K82, K83		KC1, KC2	
	Age	Count	Age	Count	Age	Count	Age	Count	Age	Count
1992	M	15.0	M	15.0	M	16.0	M	19.0	M	9.0
1993	M	18.7	M	21.7	M	21.0	1	17.5	M	24.0
1994	M	15.7	M	18.3	M	18.3	2	12.0	M	17.5
1995	1	15.7	M	22.3	M	20.3	3	19.0	M	24.0
1996	2	13.7	M	18.7	M	17.5				
1997	3	18.3	M	18.7	M	19.8				
1999	5	22.3	1	17.7	M	20.8				

[1] Mean number of species/block

Table 19. Average rank[1] of abundance of the 15 most common bird species within mature aspen and harvested study blocks, Del Rio, 1992-1999.

Mature	Avg. rank	1-2 years	Avg. rank	3-4 years	Avg. rank	5-6 years	Avg.rank	7-8 years	Avg. Rank
LEFL	1.4	WTSP	1.5	CCSP	1.8	LISP	1.0	YEWA	1.0
WTSP	2.0	LISP	1.8	LISP	1.8	COYE	2.0	COYE	2.0
SWTH	3.6	DEJU	3.5	WTSP	3.8	CCSP	3.0	WTSP	3.0
YEWA	4.4	AMRO	6.8	COYE	4.4	WTSP	4.0	RWBL	4.0
OVEN	4.7	BHCO	7.8	ALFL	6.4	ALFL	5.0	CCSP	5.0
AMRE	8.9	COSN	7.8	LEYE	7.0	BHCO	6.0	LISP	6.0
REVI	9.0	AMRE	8.5	YEWA	8.4	COSN	7.0	OCWA	7.0
BHCO	9.1	YEWA	8.8	BHCO	9.0	OCWA	8.0	ALFL	8.0
WAVI	9.1	CEWA	9.3	DEJU	9.2	YEWA	9.0	COSN	9.0
YBSA	9.4	CCSP	9.3	LEFL	9.4	RWBL	10.0	BHCO	10.0
LISP	10.4	LEFL	9.3	COSN	9.8				
RBNU	10.6	LEYE	9.3	OCWA	9.8				
AMRO	10.7	SOSA	9.3	SPSA	9.8				
PHVI	10.7	SWTH	9.3	WAVI	9.8				
SOVI	10.9	PISI	9.8	SWTH	10.0				

[1] Rank is based on the number of detections observed in a given year (Appendix B). Average rank is the arithmetic average of the annual ranks. For the purposes of generating an average rank, a species in Appendix B not ranked in a given year was given a rank of 11.

Table 20. Average rank[1] of abundance of the ten most common bird species in mature aspen and harvested study blocks surveyed at Tate Creek, 1992-1995.

Mature	Avg. Rank	1-2 years	Avg. Rank	3-4 years	Avg. Rank
WTSP	1.5	LISP	3.0	LISP	1.0
YRWA	4.0	WTSP	3.5	CCSP	2.0
LEFL	4.5	AMRO	4.0	CEWA	3.0
WAVI	5.3	DEJU	6.5	DEJU	4.0
YEWA	6.0	YEWA	6.5	WTSP	5.0
AMRE	6.8	LEFL	6.5	AMRO	6.0
YBSA	7.5	YRWA	7.0	NOFL	7.0
RBGR	8.3	SAVS	7.5	ALFL	8.0
SWTH	8.5	RWBL	8.0	BHCO	9.0
OVEN	9.3	BHCO	8.5	PISI	10.0

[1] Rank is based on the number of detections observed in a given year (Appendix B). Average rank is the arithmetic average of the annual ranks. For the purposes of generating an average rank, a species in Appendix B not ranked in a given year was given a rank of 11.

Table 21. Abundance[1] of rare and endangered species in mature aspen and harvested study blocks at Del Rio, 1992-1999. Stand ages: M, mature forest; 1-2, one- to two-year-old clearcut; 2-3, two- to three-year-old clearcut; etc. X = species observed only incidentally; blank cells = not surveyed.

	Philadelphia Vireo					Connecticut Warbler					Black-throated Green Warbler					Le Conte's Sparrow				
Year	M	1-2	3-4	5-6	7-8	M	1-2	3-4	5-6	7-8	M	1-2	3-4	5-6	7-8	M	1-2	3-4	5-6	7-8
1992	X					0.3					X					0.0				
1993	2.0					0.1					1.2					0.0				
1994	0.9		0.0			0.1		0.0			0.5		0.0			0.0		0.0		
1995	2.3	X	0.0			0.4	0.0	0.0			1.7	0.0	0.0			0.0	0.0	0.0		
1996	2.4	0.0		0.0		X	0.7		0.0		0.4	0.0		0.0		0.0	0.0		0.0	
1997	2.3	0.0	0.3	0.0		0.4	X	0.0	0.5		1.1	0.0	0.0	0.0		0.0	0.0	0.0	0.0	
1999	0.3	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.5
Mean	1.5	0.0	0.1	0.0	0.0	0.3	0.2	0.0	0.2	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.5

[1] Mean number of detections/block

Table 22. Results of repeated-measures ANOVA and follow-up one-way ANOVA and Duncan's multiple range tests for bird species for which abundance was affected by a significant interaction between stand age and year, Del Rio, 1995-1997. Three younger clearcuts (YC) were one, two, and three years old, and two older clearcuts (OC) were four, five, and six years old, in 1995-1997. Seven mature forests (M) were unharvested.

Species	Repeated-measures ANOVA		Duncan's multiple range tests			
	$F_{(4,18)}$	p	Year	1-way ANOVA	$F_{(2,11)}$	p
Alder Flycatcher	16.98	<0.001	1995	OC>(YC,M)[a]	33.8	<0.0001
			1996	OC>(YC,M)	32.4	<0.0001
			1997	OC>YC>M	129.8	<0.0001
Clay-colored Sparrow	3.16	0.039	1995	OC>(M,YC)	49.0	<0.0001
			1996	OC>(M,YC)	23.3	<0.0001
			1997	(OC,YC)>M	20.6	<0.0001
Common Yellowthroat	3.26	0.035	1995	OC>(M,YC)	398.7	<0.0001
			1996	OC>(M,YC)	703.7	<0.0001
			1997	(OC,YC)>M	39.4	<0.0001
Lesser Yellowlegs	7.05	0.008	1995	no differences	1.7	0.24
			1996	YC>M	4.2	0.05
			1997	(YC,OC)>M	8.4	0.009
Lincoln's Sparrow	19.68	<0.001	1995	OC>(M,YC)	15.9	0.001
			1996	(OC,YC)>M	60.0	<0.0001
			1997	OC>YC>M	187.4	<0.0001

...continued

Table 22. (continued)

Species	Repeated-measures ANOVA		Duncan's multiple range tests			
	$F_{(4,18)}$	p	Year	1-way ANOVA	$F_{(2,11)}$	p
Orange-crowned Warbler	3.92	0.018	1995	OC>(M,YC)	20.2	0.0005
			1996	OC>(M,YC)	15.0	0.0014
			1997	OC>(M,YC)	28.0	0.0001
White-throated Sparrow	2.99	0.047	1995	M>YC	4.9	0.04
			1996	no differences	1.19	0.35
			1997	(M,YC)>OC	9.4	0.006

[a] Relationship among stand ages is indicated. For example, in 1995, Alder Flycatcher was more abundant in older clearcuts than in either young clearcuts or mature stands, whereas White-throated Sparrow was more abundant in mature stands than young clearcuts only.

Table 23. The total number and percent of detections of bird species most often found in mature aspen stands that were also found in cutblocks in Del Rio, 1996 and 1997.

Species	No. of detections	No.of dections in mature stands	Percent of detections in mature stands	No. of detections in cutblocks	Percent of detetections in cutblocks	No. and percent of detections in retention patches or trees	
Philadelphia Vireo	17	16	94	1	6	1	100
Red-eyed Vireo	76	68	89	8	11	8	100
Rose-breasted Grosbeak	34	27	79	7	21	7	100
Swainson's Thrush	171	147	86	24	14	24	100
Warbling Vireo	43	36	84	7	16	7	100
Least Flycatcher	232	197	85	35	15	32	91
Yellow-bellied Sapsucker	46	37	80	9	20	8	89
Tennessee Warbler	41	29	71	12	29	10	83
American Redstart	106	87	82	19	18	15	79
Yellow Warbler	152	101	66	51	34	39	76
White-throated Sparrow	225	133	59	92	41	56	61

Table 24. Abundance[1] of the 10 most commonly detected bird species in coniferous- and deciduous-leading stands, Murray River, 1995.

Rank	Deciduous-leading stands		Coniferous-leading stands	
	Species	Mean	Species	Mean
1	Yellow-rumped Warbler	2.63	Yellow-rumped Warbler	1.16
2	Swainson's Thrush	0.90	Warbling Vireo	0.80
3	Black-throated Green Warbler	0.73	Dark-eyed Junco	0.64
4	Warbling Vireo	0.47	Black-throated Green Warbler	0.56
5	Golden-crowned Kinglet	0.43	Pine Siskin	0.56
6	Dark-eyed Junco	0.37	Yellow-bellied Sapsucker	0.52
7	Brown Creeper	0.33	Swainson's Thrush	0.40
8	Red-breasted Nuthatch	0.30	Golden-crowned Kinglet	0.40
9	Western Tanager	0.30	White-throated Sparrow	0.40
10	Pine Siskin	0.27	Chipping Sparrow	0.36

[1] Mean number of detections per point count.

Table 25. Ranks[1] of the 10 most commonly detected species in mature aspen stands at Del Rio, 1992-1999, and Tate Creek, 1992-1995, and in mature mixed-wood stands at Murray River, 1995.

Rank	Del Rio mature aspen	Tate Creek mature aspen	Murray mature mixed-wood
1	Least Flycatcher	White-throated Sparrow	Yellow-rumped Warbler
2	White-throated Sparrow	Yellow-rumped Warbler	Warbling Vireo
3	Swainson's Thrush	Least Flycatcher	Dark-eyed Junco
4	Yellow Warbler	Yellow Warbler	Black-throated Green Warbler
5	Ovenbird	Warbling Vireo	Pine Siskin
6	American Redstart	American Redstart	Yellow-bellied Sapsucker
7	Red-eyed Vireo	Swainson's Thrush	Swainson's Thrush
8	Brown-headed Cowbird	Brown-headed Cowbird	Golden-crowned Kinglet
9	Warbling Vireo	Ovenbird	White-throated Sparrow
10	Yellow-bellied Sapsucker	Rose-breasted Grosbeak	Chipping Sparrow

[1] Based on the number of detections observed across all years of the study at a particular study area

Table 26. Species found only in mature mixed-wood (Murray River, 1995) or only in mature aspen (Del Rio, 1992-1999, and Tate Creek 1992-1995) forests during surveys. Ducks, geese, shorebirds, rails and cranes are not included in this overview. Species are in order of abundance.

Mature aspen		Mature mixed-wood
≤ 5 observations	> 5 observations	≤ 5 observations
Ruffed Grouse	Brown-headed Cowbird	Black-backed Woodpecker
Wilson's Warbler	Black-capped Chickadee	Winter Wren
Swamp Sparrow	Evening Grosbeak	Three-toed Woodpecker
Clay-colored Sparrow	Blackpoll Warbler	Magnolia Warbler
Sharp-shinned Hawk	Connecticut Warbler	Barred Owl
Alder Flycatcher	Northern Waterthrush	Varied Thrush
White-breasted Nuthatch	House Wren	
Red-winged Blackbird	Black-and-White Warbler	
Great Gray Owl	Baltimore Oriole	
Eastern Phoebe	Downy Woodpecker	
American Crow	American Pipit	
Blue Jay	Brewer's Blackbird	
Golden-crowned Sparrow		
Song Sparrow		

Table 27. Owls detected during calling surveys in aspen stands, Del Rio, 17 March-17 April 1997.

Species	No. detections	Detections/calling station-night [1]	Estimated no. of territories
Great Gray Owl	6	0.05	4
Great Horned Owl	4	0.03	3

[1] Number of detections divided by the total number of calling stations surveyed during the survey period

Table 28. Habitat types associated with owls detected in and around aspen forests at Del Rio, 17 March-17 April 1997.

Date	Owl species	Estimated distance to bird (m)	Habitat description[1]
97/03/18	Great Horned	1,000	Mature aspen
97/04/04	Great Horned	250	Mature aspen
97/04/12	Great Gray	200	Mature aspen
97/04/12	Great Horned	800	Mature tamarack and black spruce with some aspen
97/04/12	Great Gray	50	Mature aspen
97/04/12	Great Gray	100	Tamarack and black spruce with some aspen
97/04/12	Great Horned	600	Mature aspen
97/04/12	Great Gray	500	Mature aspen
97/04/15	Great Horned	800	Swamp
97/04/15	Great Gray	600	Mature aspen
97/04/15	Great Gray	30	Mature aspen

[1] Based on forest cover polygons described in Booth and Harrison (1997)

Table 29. Owls detected during calling surveys in mixed-wood stands Murray River (MR), Boudreau Lake (BL) and A1 Road (A1), 17 March-17 April 1997.

Species	Total no. detections				Detections/calling station-night[1]				Estimated no. of territories			
	MR	BL	A1	All	MR	BL	A1	All	MR	BL	A1	All
Great Horned Owl	3	6	0	9	0.21	0.33	0	0.13	2	2	0	4
Northern Saw-whet Owl	1	0	0	1	0.07	0	0	0.01	1	0	0	1
Barred Owl	9	0	3	12	0.64	0	0.83	0.18	4	0	2	6

[1] Number of detections divided by the total number of calling stations surveyed during the survey period.

Table 30. Habitat types associated with owls detected in mixed-wood stands at Murray River, Boudreau Lake and A1 Road, 17 March-17 April 1997.

Survey site	Date	Owl species	Estimated distance to bird (m)	Habitat description[1]
Murray River				
	97/03/27	Great Horned	250	Mature spruce/aspen
	97/03/27	Barred	350	Mature cottonwood/lodgepole pine/spruce
	97/03/27	Barred	900	Mature aspen/spruce with some cottonwood
	97/03/27	Barred	600	Mature aspen
	97/03/27	Barred	500	Mature aspen/spruce with some cottonwood
	97/04/10	Saw-whet	400	Aspen with some cottonwood and spruce
	97/04/10	Barred	900	Mature aspen
	97/04/10	Barred	50	Mature lodgepole pine/spruce/aspen
	97/04/10	Barred	50	Mature lodgepole pine/spruce/aspen
	97/04/10	Barred	150	Mature spruce/aspen
	97/04/10	Barred	1,000	Mature black spruce
	97/04/10	Barred	750	Mid-aged cottonwood (41-60 years)
	97/04/10	Great Horned	1,000	Mature aspen/cottonwood/spruce
	97/04/10	Great Horned	600	Mature cottonwood/lodgepole pine/spruce
A1 Road				
	97/04/09	Barred	400	Mature spruce/pine with some aspen and cottonwood
	97/04/09	Barred	100	Mature aspen
	97/04/09	Barred	150	Mature aspen
	97/04/09	Barred	1,000	Mid-aged aspen/cottonwood (61-80 years)
	97/04/09	Barred	1,000	Mature aspen/spruce
	97/04/17	Barred	900	Mature aspen/spruce
	97/04/17	Barred	1,000	Mid-aged aspen/spruce (61-80 years)
Boudreau Lake				
	97/04/08	Great Horned	250	Mature spruce/aspen
	97/04/08	Great Horned	250	Mature aspen/cottonwood
	97/04/08	Great Horned	200	Mature aspen/cottonwood
	97/04/08	Great Horned	350	Mature spruce/aspen with some cottonwood
	97/04/08	Great Horned	200	Mid-aged aspen (41-60 years)
	97/04/16	Great Horned	450	Mature spruce/aspen with some cottonwood
	97/04/16	Great Horned	10	Mature spruce/aspen with some cottonwood

[1] Based on forest cover polygons described in Booth and Harrison (1997)

APPENDICES

Appendix A. Breeding bird species recorded at Del Rio and Tate Creek, 1992-1999. Total number for each species recorded on surveys is indicated. Species always recorded incidentally in a given year are indicated with a "0".

			Del Rio								Tate Creek				
Common Name	*Scientific Name*	Code	92	93	94	95	96	97	99	Total	92	93	94	95	Total
GEESE AND DUCKS															
American Wigeon	*Anas americana*	AMWI							1	1					
Blue-winged Teal	*Anas discors*	BWTE						2		2					
Bufflehead	*Bucephala albeola*	BUFF		0			0			0					
Green-winged Teal	*Anas crecca*	GWTE			0	0		6	2	8					
Canada Goose	*Branta canadensis*	CAGO		0	0	0		0		0			0	0	0
Mallard	*Anas platyrhynchos*	MALL		0	0	0		3	2	5			0		0
HAWKS															
American Kestrel	*Falco sparverius*	AMKE							4	4					
Merlin	*Falco columbarius*	MERL		0						0					
Northern Goshawk	*Accipiter gentilis*	NOGO			0					0					
Northern Harrier	*Circus cyaneus*	NOHA							1	1					
Red-tailed Hawk	*Buteo jamaicensis*	RTHA	0		0	0	0	1	1	2	0				0
Sharp-shinned Hawk	*Accipiter striatus*	SSHA		1	0	0	0			1		1			1
GROUSE															
Ruffed Grouse	*Bonasa umbellus*	RUGR			0	1	0	0		1			2	1	3
RAILS AND CRANES															
Sora	*Porzana carolina*	SORA			1			4		5					
Sandhill Crane	*Grus canadensis*	SACR			0					0					
SHOREBIRDS															
Common Snipe	*Gallinago gallinago*	COSN			0	3	2	17	49	71		5	2	5	12
Killdeer	*Charadrius vociferus*	KILL			0	1	2	0	5	8			0		0
Lesser Yellowlegs	*Tringa flavipes*	LEYE			17	11	6	21	14	69			0	2	2
Solitary Sandpiper	*Tringa solitaria*	SOSA			1	1	4	20	6	32		1	0		1
Spotted Sandpiper	*Actitus macularia*	SPSA			5	1	3	2		11			0		0
OWLS															
Great Gray Owl	*Strix nebulosa*	GGOW				1			0	1					

Appendix A. (continued)

Common Name	*Scientific Name*	Code	Del Rio								Tate Creek				
			92	93	94	95	96	97	99	Total	92	93	94	95	Total
Great Horned Owl	*Bubo virginianus*	GHOW		0	0					0	0				0
NIGHTJARS															
Common Nighthawk	*Chordeiles minor*	CONI	0		0	0	0	0		0		0			0
WOODPECKERS															
Black-backed Woodpecker	*Picoides arcticus*	BBWO					0			0					
Downy Woodpecker	*Picoides pubescens*	DOWO		2	0	4		0	3	9	0			2	2
Hairy Woodpecker	*Picoides villosus*	HAWO	2	0	0	2		7	2	13				0	0
Northern Flicker	*Colaptes auratus*	NOFL	0	0	0	1	1	1	12	15		6	0	6	12
Three-toed Woodpecker	*Picoides tridactylus*	TTWO	0				0			0					
Yellow-bellied Sapsucker	*Sphyrapicus varius*	YBSA	18	74	36	28	15	31	23	225	4	14	7	2	27
Unidentified Woodpecker			4							4	4				4
FLYCATCHERS															
Alder Flycatcher	*Empidonax alnorum*	ALFL	2		4	12	19	45	39	121				6	6
Dusky Flycatcher	*Empidonax oberholseri*	DUFL				1				1					
Eastern Phoebe	*Sayonis phoebe*	EAPH			1					1					
Least Flycatcher	*Empidonax minimus*	LEFL	82	180	109	96	83	149	91	790	17	26	8	13	64
Olive-sided Flycatcher	*Contopus borealis*	OSFL	1		0	0		2		3	1				1
Say's Phoebe	*Sayonis saya*	SAPH			1			0		1		0	0		0
Western Wood-Pewee	*Contopus sordidulus*	WWPE	4	4	2	0	1	2	3	16	6	0	0		6
Yellow-bellied Flycatcher	*Empidonax flaviventris*	YBFL				0				0					
VIREOS															
Philadelphia Vireo	*Vireo philadelpicus*	PHVI	0	20	9	16	17	17	1	80	0	9	1	2	12
Red-eyed Vireo	*Vireo olivaceus*	REVI	23	28	22	23	33	44	25	198	3	6	5	4	18
Blue-headed Vireo	*Vireo solitarius*	BHVI	19	3	1	1		3	2	29	2	3			5
Warbling Vireo	*Vireo gilvus*	WAVI	24	34	14	31	14	30	24	171	7	19	6	12	44
CROWS AND ALLIES															
American Crow	*Corvus brachyrhynchos*	AMCR	1	0	0					1					
Blue Jay	*Cyanocitta cristata*	BLJA	0						1	1					
Common Raven	*Corvus corax*	CORA	0	3	0	0	0	0	2	5		1	0		1

Appendix A. (continued)

Common Name	*Scientific Name*	Code	Del Rio								Tate Creek				
			92	93	94	95	96	97	99	Total	92	93	94	95	Total
Gray Jay	*Perisoreus canadensis*	GRJA	1	20	4	9	8	5	5	52	1	1	2	0	4
LARKS															
Horned Lark	*Eremophila alpestris*	HOLA												0	0
SWALLOWS															
Barn Swallow	*Hirundo rustica*	BASW						1		1				1	1
Tree Swallow	*Tachycineta bicolor*	TRSW			0	3	3	2	12	20		1	1	3	5
Violet-green Swallow	*Tachycineta thalassina*	VGSW				0				0					
CHICKADEES															
Black-capped Chickadee	*Parus atricapillus*	BCCH	16	6	13	6	1	2	8	52	6		2	1	9
Boreal Chickadee	*Parus hudsonicus*	BOCH									5				5
Unidentified chickadee			0							0	2				2
NUTHATCHES															
Red-breasted Nuthatch	*Sitta canadensis*	RBNU	7	24	25	2	2	2	5	67	2	9	4	0	15
White-breasted Nuthatch	*Sitta carolinensis*	WBNU		2						2	0				0
WRENS AND CREEPERS															
House Wren	*Troglodytes aedon*	HOWR	2	3	2	8	4	3	3	25		0	0	0	0
Brown Creeper	*Certhia americana*	BRCR	0				0	1		1					
KINGLETS															
Golden-crowned Kinglet	*Regulus satrapa*	GCKI			3			1		4					
Ruby-crowned Kinglet	*Regulus calendula*	RCKI			2					2		3	0		3
THRUSHES															
American Robin	*Turdus migratorius*	AMRO	11	46	11	24	18	27	30	167	1	14	11	12	38
Hermit Thrush	*Catharus guttatus*	HETH	1	3	1	1	2	2		10		3	2	2	7
Mountain Bluebird	*Sialia currocoides*	MOBL											2	7	9
Swainson's Thrush	*Catharus ustulatus*	SWTH	99	90	26	86	70	101	52	524	10	9	4	10	33
Townsend's Solitaire	*Myadestes townsendii*	TOSO											1		1
Varied Thrush	*Ixoreus naevius*	VATH			0					0					

Appendix A. (continued)

			Del Rio									Tate Creek				
Common Name	*Scientific Name*	Code	92	93	94	95	96	97	99	Total		92	93	94	95	Total
PIPITS AND WAXWINGS																
American Pipit	*Anthus rubescens*	AMPI			0					0			9			9
Cedar Waxwing	*Bombycilla cedrorum*	CEWA	0	2	0	13	0	0		15				0	15	15
WARBLERS																
American Redstart	*Setophaga ruticilla*	AMRE	15	19	17	42	48	59	11	211		5	9	6	16	36
Black-and-white Warbler	*Mniotilta varia*	BAWW		4	1	4	1		5	15			4	2		6
Blackpoll Warbler	*Dendroica coronata*	BPWA		0	2			1	1	4		1	6	4	6	17
Black-throated Green Warbler	*Dendroica nigrescens*	BTNW	0	12	5	12	3	8	6	46	0	1	4	1	6	
Common Yellowthroat	*Geothlypis trichas*	COYE			4	25	17	60	83	189						
Connecticut Warbler	*Oporornis agilis*	COWA	3	1	1	3	2	4	3	17			3	0	1	4
Magnolia Warbler	*Dendroica magnolia*	MAWA			0					0						
Mourning Warbler	*Oporornis philadelphia*	MOWA		0	1	0	5	7	4	17		2	1	1	3	7
Northern Waterthrush	*Seiurus aurocapillus*	NOWA		1	4	3	2	11		21				0	1	1
Orange-crowned Warbler	*Vermivora celata*	OCWA		1	4	20	4	11	25	65		0	2		7	9
Ovenbird	*Seiurus aurocapillus*	OVEN	52	80	50	45	41	56	28	352		2	11	5	11	29
Tennessee Warbler	*Vermivora peregrina*	TEWA	4	3	8	0	12	29		56		1	6	4		11
Wilson's Warbler	*Wilsonia pusilla*	WIWA	2		1				0	3		0			1	1
Yellow Warbler	*Dendroica petechia*	YEWA	46	97	49	63	53	100	99	507		19	23	6	14	62
Yellow-rumped Warbler	*Dendroica coronata*	YRWA	25	73	65	56	27	34	24	304		2	32	18	16	68
SPARROWS																
Chipping Sparrow	*Spizella passerina*	CHSP	5	0	3	2		8	9	27		8	6	3	6	23
Clay-colored Sparrow	*Spizella pallida*	CCSP		0	24	43	34	70	95	266		1	2	1	31	35
Dark-eyed Junco	*Junco hyemalis*	DEJU	8	16	27	33	17	27	12	140		5	12	12	15	44
Fox Sparrow	*Passerella iliaca*	FOSP						0	6	6			0	0		0
Golden-crowned Sparrow	*Zonotrichia atricapilla*	GCSP				1				1						
Le Conte's Sparrow	*Ammodramus leconteii*	LCSP							6	6						
Lincoln's Sparrow	*Melospiza lincolnii*	LISP	1	5	33	105	45	142	144	475			11	15	52	78
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	RBGR	15	15	9	23	12	23	16	113		3	16	5	5	29
Savannah Sparrow	*Passerculus sandwichensis*	SAVS			2		2	6	3	13			0	5	2	7
Song Sparrow	*Melospiza melodia*	SOSP	1		4	2		1	0	8						

Appendix A. (continued)

			Del Rio								Tate Creek				
Common Name	*Scientific Name*	Code	92	93	94	95	96	97	99	Total	92	93	94	95	Total
Swamp Sparrow	*Melospiza gerogiana*	SWSP		0	0	5	2	0	11	18					
Western Tanager	*Piranga ludoviciana*	WETA	6	10	5	11	13	13	9	67				1	1
White-crowned Sparrow	*Zonotrichia leucophrys*	WCSP	0							0	0				0
White-throated Sparrow	*Zonotrichia albicollis*	WTSP	122	117	75	145	99	127	151	836	57	51	17	37	162
BLACKBIRDS															
Baltimore Oriole	*Icterus galbula*	BAOR		6	2	3	5	2	3	21					
Brewer's Blackbird	*Euphagus cyanocephalus*	BRBL				2		4		6		8	28	6	42
Brown-headed Cowbird	*Molothrus ater*	BHCO	21	78	11	42	23	64	63	302	0	20	2	17	39
Red-winged Blackbird	*Agelaius phoeniceus*	RWBL	2	0	1	0	1	17	39	60			5	2	7
Rusty Blackbird	*Euphagus carolinus*	RUBL							10	10					
FINCHES															
American Goldfinch	*Carduelis tristis*	AMGO											0		0
Evening Grosbeak	*Coccothraustes vespertinus*	EVGR	0	25	0	35	2	3		65		12	0		12
Pine Grosbeak	*Pinicola enucleator*	PIGR	1	1	0					2					
Pine Siskin	*Carduelis pinus*	PISI	5	3	0	10	8	13	17	56		4	0	6	10
Purple Finch	*Carpodacus purpureus*	PUFI		1	3		2	1	5	12				1	1
White-winged Crossbill	*Loxia leucoptera*	WWCR		1		72	1		3	77			0	10	10
Total # Individuals			651	1114	721	1193	789	1455	1319	7242	177	380	203	374	1134
Total # species during surveys			35	41	50	53	48	59	59	82	25	41	35	44	59
Total # species			47	55	77	67	58	69	62	100	35	46	55	50	74

Appendix B. Yearly ranks of the 10 most common bird species observed in each year in mature aspen forests and harvested study blocks, Del Rio, 1992-1999, and Tate Creek, 1992-1995. Cell values are year and species rank, the latter in brackets. Only the top 10 most abundant species are presented for a given year and age class. Migratory flocks of species such as White-winged Crossbill, Evening Grosbeak and American Pipit were generally recorded only occasionally and are not included in this analysis.

Species	Mature	1-2 year old	3-4 year old	5-6 year old	7-8 year old
Del Rio					
Alder Flycatcher			94(8),95(8),96(3) 97(5),99(8)	99(5)	99(8)
American Redstart	95(8),96(4),97(6)	95(6),96(6)			
American Robin	93(9)	95(8),96(8) 97(6),99(5)	96(10)		
Black-capped Chickadee					
Brown-headed Cowbird	92(9),93(6),95(10) 97(9),99(8)	95(9),97(8), 99(3)	95(7),96(7), 97(9)	99(6)	99(10)
Cedar Waxwing		95(4)			
Chipping Sparrow					
Clay-colored Sparrow		96(4)	94(2),95(2),96(1) 97(2),99(2)	99(3)	99(5)
Common Snipe		97(5),99(4)	99(5)	99(7)	99(9)
Common Yellowthroat			94(9),95(3),96(4) 97(3),99(3)	99(2)	99(2)
Dark-eyed Junco	94(9)	95(2),96(3) 97(3),99(6)	94(6),97(7)		
Least Flycatcher	92(3),93(1),94(1),95(2) 96(1),97(1),99(1)	97(7),99(8)	94(7),95(10) 96(8)		
Lesser Yellowlegs		96(5),97(10)	94(3),95(9),97(6) 99(6)		
Lincoln's Sparrow	95(7)	95(3),96(1) 97(1),99(2)	94(1),95(1),96(5) 97(1),99(1)	99(1)	99(6)
Mourning Warbler		96(9)			
Orange-crowned Warbler			95(6),96(10)	99(8)	99(7)
Ovenbird	92(4),93(5),94(4) 95(5) 96(5) 97(5),99(5)				
Philadelphia Vireo	96(9)				
Pine Siskin		96(10),99(7)			
Red-breasted Nuthatch	94(8)				
Red-eyed Vireo	92(8),94(10),96(7) 97(7),99(9)				
Red-winged Blackbird				99(10)	99(4)
Rusty Blackbird			99(7)		
Solitary Sandpiper		97(4)	99(10)		
Solitary Vireo	92(10)				
Song Sparrow			94(10)		
Spotted Sandpiper			94(5)		
Swainson's Thrush	92(2),93(4),94(7),95(3) 96(3),97(2),99(4)	95(10),96(7) 99(9)	96(9),97(8)		
Tree Swallow			99(9)		

...continued

Appendix B: (continued)

Species	Mature	1-2 year old	3-4 year old	5-6 year old	7-8 year old
Warbling Vireo	92(7),93(10),95(9) 97(10),99(6)		94(5)		
Western Wood-Pewee					
White-throated Sparrow	92(1),93(2),94(2) 95(1) 96(2),97(3),99(3)	95(1),96(2) 97(2),99(1)	94(4),95(5),96(2) 97(4),99(4)	99(4)	99(3)
Yellow Warbler	92(5),93(3),94(5),95(6) 96(6),97(4),99(2)	95(5),97(9) 99(10)	95(4),96(6) 97(10)	99(9)	99(1)
Yellow-bellied Sapsucker	93(7),94(6),96(10) 99(10)	95(7)			
Yellow-rumped Warbler	92(6),93(8),94(3),95(4) 96(8),97(8),99(7)				
Tate Creek					
Alder Flycatcher			95(8)		
American Redstart	92(9),93(9),94(6),95(3)				
American Robin		93(6),94(2)	95(6)		
Black-capped Chickadee	92(8)				
Brown-headed Cowbird	93(8),95(8)	93(7),94(10)	95(9)		
Cedar Waxwing			95(3)		
Chipping Sparrow	92(5)	94(7)			
Clay-colored Sparrow			95(2)		
Common Snipe		94(8)			
Dark-eyed Junco	92(10),94(10)	93(10),94(3)	95(4)		
Least Flycatcher	92(3),93(6),94(4),95(5)	93(2)			
Lincoln's Sparrow		93(5),94(1)	95(1)		
Northern Flicker			95(7)		
Ovenbird	94(8),95(7)	93(9)			
Pine Siskin			95(10)		
Red-eyed Vireo	94(7)				
Red-winged Blackbird		94(5)			
Rose-breasted Grosbeak	93(3),94(9),95(10)				
Savannah Sparrow		94(4)			
Swainson's Thrush	92(4),93(10),95(9)				
Warbling Vireo	92(6),93(4),94(5),95(6)	93(8)			
Western Wood-Pewee	92(7)				
White-throated Sparrow	92(1),93(2),94(2),95(1)	93(1),94(6)	95(5)		
Yellow Warbler	92(2),93(7),95(4)	93(4),94(9)			
Yellow-bellied Sapsucker	93(5),94(3)				
Yellow-rumped Warbler	93(2),94(1),95(2)	93(3)			

Appendix C. Mean number and standard errors of detections per point count per study block of forest birds in mature aspen forest (M), young clearcuts (YC; 1-3 years) and old clearcuts (OC; 4-8 years) in 1995, 1996, 1997 and 1999. In 1995, 1996 and 1997, mature forests included blocks B1, B2, B3, C1, C2, CC and NC, young forests included blocks C92, DM and PG, and old clearcuts included blocks PS and TC. In 1999, mature forests included C1, C2, CC and NC; young forests included, B1, B2 and B3; and old forests included DM, C92, PG, PS and TC.

Species	Stand	1995		1996		1997		1999	
	age	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Alder Flycatcher	M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	YC	0.00	0.00	0.13	0.13	0.67	0.08	0.00	0.00
	OC	0.50	0.17	1.00	0.25	0.83	0.08	0.55	0.07
American Redstart	M	0.51	0.09	0.77	0.16	0.54	0.07	0.19	0.09
	YC	0.14	0.14	0.17	0.17	0.08	0.08	0.03	0.03
	OC	0.04	0.04	0.06	0.06	0.25	0.08	0.00	0.00
American Robin	M	0.19	0.02	0.20	0.06	0.10	0.04	0.21	0.11
	YC	0.11	0.03	0.13	0.07	0.03	0.03	0.33	0.08
	OC	0.17	0.17	0.25	0.13	0.25	0.08	0.08	0.04
Brown-headed Cowbird	M	0.30	0.06	0.20	0.06	0.40	0.08	0.38	0.17
	YC	0.11	0.07	0.00	0.00	0.17	0.10	0.44	0.03
	OC	0.54	0.13	0.75	0.13	0.88	0.04	0.43	0.13
Clay-colored Sparrow	M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	YC	0.06	0.06	0.58	0.25	1.31	0.37	0.03	0.03
	OC	1.71	0.46	1.25	0.25	0.79	0.04	0.95	0.16
Common Yellowthroat	M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	YC	0.03	0.03	0.04	0.04	1.03	0.23	0.00	0.00
	OC	1.00	0.08	1.00	0.02	0.92	0.08	1.12	0.15
Dark-eyed Junco	M	0.08	0.05	0.02	0.02	0.01	0.01	0.04	0.04
	YC	0.56	0.25	0.63	0.22	0.19	0.07	0.28	0.03
	OC	0.25	0.25	0.06	0.06	0.04	0.04	0.00	0.00
Gray Jay	M	0.10	0.06	0.07	0.05	0.04	0.02	0.00	0.00
	YC	0.03	0.03	0.13	0.13	0.03	0.03	0.00	0.00
	OC	0.00	0.00	0.06	0.06	0.04	0.04	0.08	0.08
Least Flycatcher	M	1.06	0.26	1.30	0.31	1.48	0.37	1.48	0.49
	YC	0.06	0.06	0.04	0.04	0.11	0.07	0.17	0.05
	OC	0.58	0.33	0.56	0.06	0.42	0.08	0.23	0.06
Lesser Yellowlegs	M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	YC	0.03	0.03	0.17	0.08	0.25	0.08	0.03	0.03
	OC	0.00	0.00	0.13	0.13	0.25	0.17	0.08	0.06
Lincoln's Sparrow	M	0.45	0.13	0.05	0.04	0.05	0.02	0.02	0.02
	YC	0.53	0.19	1.17	0.15	1.83	0.13	0.81	0.17
	OC	2.00	0.25	0.88	0.13	1.25	0.17	1.02	0.29
Northern Waterthrush	M	0.01	0.01	0.04	0.04	0.05	0.04	0.10	0.06
	YC	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.03
	OC	0.08	0.00	0.00	0.00	0.04	0.04	0.08	0.05
Orange-crowned Warbler	M	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	YC	0.11	0.11	0.00	0.00	0.08	0.05	0.00	0.00
	OC	0.54	0.04	0.25	0.13	0.33	0.08	0.40	0.10

...continued

Appendix C. (continued)

Species	Stand age	1995 Mean	1995 SE	1996 Mean	1996 SE	1997 Mean	1997 SE	1999 Mean	1999 SE
Ovenbird	M	0.54	0.15	0.73	0.16	0.67	0.12	0.58	0.18
	YC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	OC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Philadelphia Vireo	M	0.19	0.06	0.30	0.06	0.19	0.05	0.02	0.02
	YC	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00
	OC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rose-breasted Grosbeak	M	0.24	0.05	0.18	0.07	0.21	0.05	0.19	0.02
	YC	0.06	0.06	0.04	0.04	0.03	0.03	0.00	0.00
	OC	0.04	0.04	0.06	0.06	0.17	0.00	0.12	0.08
Red-breasted Nuthatch	M	0.02	0.02	0.04	0.02	0.02	0.02	0.10	0.05
	YC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	OC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Red-eyed Vireo	M	0.24	0.09	0.54	0.07	0.46	0.07	0.35	0.05
	YC	0.03	0.03	0.00	0.00	0.03	0.03	0.06	0.03
	OC	0.08	0.00	0.19	0.19	0.17	0.08	0.10	0.04
Solitary Sandpiper	M	0.00	0.00	0.04	0.04	0.01	0.01	0.00	0.00
	YC	0.03	0.03	0.08	0.04	0.03	0.03	0.06	0.06
	OC	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00
Swainson's Thrush	M	0.94	0.12	1.07	0.12	1.04	0.10	0.77	0.09
	YC	0.11	0.11	0.13	0.13	0.17	0.13	0.17	0.08
	OC	0.13	0.13	0.44	0.06	0.21	0.04	0.13	0.07
Tennessee Warbler	M	0.00	0.00	0.16	0.04	0.24	0.06	0.00	0.00
	YC	0.00	0.00	0.04	0.04	0.11	0.11	0.00	0.00
	OC	0.00	0.00	0.13	0.13	0.04	0.04	0.00	0.00
Warbling Vireo	M	0.33	0.12	0.21	0.09	0.30	0.10	0.46	0.14
	YC	0.03	0.03	0.08	0.08	0.06	0.06	0.03	0.03
	OC	0.08	0.08	0.00	0.00	0.13	0.04	0.02	0.02
Western Tanager	M	0.12	0.02	0.23	0.09	0.15	0.05	0.17	0.08
	YC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	OC	0.04	0.04	0.00	0.00	0.00	0.00	0.02	0.02
White-throated Sparrow	M	1.26	0.14	1.16	0.24	0.82	0.05	0.83	0.12
	YC	0.64	0.18	0.63	0.00	0.83	0.10	0.97	0.27
	OC	0.67	0.08	1.19	0.19	0.38	0.04	1.00	0.06
Yellow-bellied Sapsucker	M	0.23	0.06	0.25	0.06	0.27	0.04	0.33	0.08
	YC	0.14	0.07	0.04	0.04	0.03	0.03	0.11	0.06
	OC	0.17	0.00	0.00	0.00	0.08	0.08	0.05	0.02
Yellow Warbler	M	0.45	0.10	0.68	0.17	0.76	0.14	0.88	0.18
	YC	0.14	0.14	0.08	0.08	0.17	0.10	0.17	0.00
	OC	0.83	0.08	0.81	0.06	0.96	0.13	0.82	0.32
Yellow-rumped Warbler	M	0.65	0.10	0.48	0.06	0.40	0.08	0.42	0.03
	YC	0.03	0.03	0.00	0.00	0.00	0.00	0.11	0.03
	OC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix D. Mean number of bird species detected per survey at five stations in two coniferous-leading mixed-wood stands and six stations in three deciduous-leading mixed-wood stands, Murray River, 1995. Each station was surveyed five times. Species seen only outside the survey period are indicated with an 'X'. Blank cells indicate no data recorded.

Species	Deciduous-leading stands	Coniferous-leading stands
Merlin	X	
Barred Owl	0.03	
Common Snipe	0.07	
Black-backed Woodpecker	0.10	0.08
Hairy Woodpecker		0.04
Northern Flicker		X
Pileated Woodpecker		X
Three-toed Woodpecker	0.03	0.04
Yellow-bellied Sapsucker	0.10	0.52
Dusky Flycatcher	0.03	
Least Flycatcher	0.13	X
Olive-sided Flycatcher		0.08
Western Wood-Pewee	0.03	0.12
Blue-headed Vireo	0.10	0.32
Philadelphia Vireo	0.03	
Red-eyed Vireo		0.04
Warbling Vireo	0.47	0.80
Common Raven	0.03	
Gray Jay	0.23	0.28
Tree Swallow	0.00	0.04
Boreal Chickadee	0.10	0.20
Red-breasted Nuthatch	0.30	0.24
Brown Creeper	0.33	0.04
Winter Wren	0.03	0.16
Golden-crowned Kinglet	0.43	0.40
Ruby-crowned Kinglet	0.10	0.08
American Robin	0.17	0.16
Swainson's Thrush	0.90	0.40
Varied Thrush		0.03
Cedar Waxwing	0.03	
American Redstart	0.07	
Black-throated Green Warbler	0.73	0.56
Magnolia Warbler	0.07	
Mourning Warbler		0.04
Orange-crowned Warbler		0.04
Ovenbird	0.03	0.12
Tennessee Warbler		0.04
Yellow Warbler	0.10	
Yellow-rumped Warbler	2.63	1.16
Chipping Sparrow	0.07	0.36
Dark-eyed Junco	0.37	0.64
Lincoln's Sparrow	0.03	0.12

...continued

Appendix D. (continued)

Species	Deciduous-leading stands	Coniferous-leading stands
Rose-breasted Grosbeak	X	X
Western Tanager	0.30	0.16
White-throated Sparrow	0.20	0.40
Pine Siskin	0.27	0.56
Purple Finch	0.03	
White-winged Crossbill	0.03	0.04
Total no. of species on surveys	37	32
Total no. of species	39	36
Mean no. detections/ survey	8.77	8.28

Appendix E. Total count of individual mammals captured in Sherman, Tomahawk and pitfall traps in mature aspen forest study blocks, Del Rio and Tate Creek, 1992-1997. Delayed funding resulted in reduced trapping effort in 1996. Pitfall sample sizes and captures are in square brackets. Pitfalls were discontinued after 1995 because high water table levels lifted traps aboveground. Sampling was discontinued in Tate Creek after 1995.

	Common name	Code	1992	1993	1994	1995	1996	1997
DEL RIO mature								
Number of blocks			9	10	10	7	7	7
Trap-nights – Sherman			2880	3200	2680	2240	1680	2240
Tomahawk			720	800	740	560	420	560
Pitfalls			[1440]	[1660]	[0]	[1120]	[0]	[0]
Peromyscus maniculatus	Deer Mouse	PEMA	169 [3]	121[1]	147	206 [7]	53	51
Clethrionomys gapperi	Red-backed Vole	CLGA	19	[3]	45	29 [3]	1	46
Microtus pennsylvanicus	Meadow Vole	MIPE	62 [13]	1[2]	1	59 [28]	3	15
Phenacomys intermedius	Heather Vole	PHIN	1			2		
Zapus hudsonius	Meadow Jumping Mouse	ZAHU						
Tamius minimus	Least Chipmunk	TAMI						
Tamiasciurus hudsonicus	Red Squirrel	TAHU	1	1	2			
Glaucomys sabrinus	Northern Flying Squirrel	GLSA						
Mustela erminea	Ermine	MUER						
Martes americana	Marten	MAAM	1	20	1	7		3
Sorex spp.	shrews	SOspp	[3]	[16]		[5]		3
TATE CREEK mature								
Number of blocks			3	2	2	2	n.a.	n.a.
Trap-nights – Sherman			480	320	240	320		
Tomahawk			120	80	60	80		
Pitfalls			[288]	[192]	[0]	[192]		
Peromyscus maniculatus			33	7	6	4		
Clethrionomys gapperi			33 [1]		2	14		
Microtus pennsylvanicus			24 [1]			31		
Phenacomys intermedius			1			3		
Zapus hudsonius								
Tamius minimus								
Tamiasciurus hudsonicus				3				
Glaucomys sabrinus					1	2		
Mustela erminea			1					
Martes americana			3	1				
Sorex spp.			1 [10]	[2]				

Appendix F. Total count of individual mammals captured in Sherman, Tomahawk and pitfall traps in harvested study blocks, one to six years old. Blocks were winter harvested. Blocks C92, PG, and DM, which were harvested winter 1994-1995, were classified as one year old in 1995. Blocks WC97, NC97 and MC97 were one year old in 1997. Blocks TC and PS were three years old in 1994.

DEL RIO harvested	1-y-old	1-y-old	2-y-old	3-y-old	3-y-old	4-y-old	5-y-old	6-y-old
Number of blocks	3	3	3	2	3	2	2	2
Survey year	1995	1997	1996	1994	1997	1996	1997	
Trap-nights – Sherman	960	960	720	560	960	640	480	640
Tomahawk	240	240	180	160	240	160	120	160
Pitfalls	[192]	[0]	[0]	[0]	[0]	[320]	[0]	[0]
Peromyscus maniculatus	63 [1]	48	12	31	14	42		5
Clethrionomys gapperi	14	5		6	16	5		14
Microtus pennsylvanicus	21 [26]	21		6	44	18 [5]		38
Phenacomys intermedius	1	1						
Zapus hudsonius					1	3	1	
Tamius minimus		1				7		
Tamiasciurus hudsonicus								
Glaucomys sabrinus								
Mustela erminea	1					3		
Martes americana	1		1		1			
Sorex spp.	1	7	1		7	[3]		10

TATE CREEK harvested	1-y-old	2-y-old	3-y-old
Number of blocks	2	2	2
Survey year	1993	1994	1995
Trap-nights – Sherman	320	240	320
Tomahawk	80	60	80
Pitfalls	[192]	[0]	[192]
Peromyscus maniculatus	20	19	19
Clethrionomys gapperi	1 [2]		6
Microtus pennsylvanicus			16 [1]
Phenacomys intermedius			
Zapus hudsonius			
Tamius minimus			
Tamiasciurus hudsonicus			
Glaucomys sabrinus			
Mustela erminea			
Martes americana			
Sorex spp.	[1]		